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F. A. KARTAK AND E. J. STEINBERG

THERMAL EFFICIENCY TEST OF THE
WATER GAS SET OF THE MADISON
GAS AND ELECTRIC COMPANY

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THERMAL EFFICIENCY TEST
OF THE
WATER GAS SET
OF THE
MADISON GAS AND ELECTRIC COMPANY

by

FRANZ AUGUST KARTAK AND ERNEST JOSEPH STEINBERG

A Thesis Submitted for the Degree of
BACHELOR OF SCIENCE IN ELECTRICAL ENGINEERING

UNIVERSITY OF WISCONSIN

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INTRODUCTION.

Water gas is obtained by the decomposition of steam in the presence of an incandescent bed of coal or coke. The hydrogen of the steam is liberated while the oxygen combines with the carbon of the coke to form carbon monoxide according to the following equation: $C + H_2O = CO + H_2$. This product possesses a good heating value, but has no luminosity. To make it useful as an illuminating gas the blue water gas is mixed with an oil gas obtained from the "cracking" of some petroleum product, and is then called carburetted water gas.

The apparatus used in the manufacture of carburetted water gas consists of a generator, carburetter and superheater. In the generator the coal or coke is first raised to an incandescent state by means of an air blast, and then steam introduced, which is decomposed by the heated fuel bed. Gases which are formed in the generator during the blast pass into the carburetter, where these partially burned gases come in contact with a secondary air blast and are burned more completely, thus giving up heat. This heat is absorbed by the lining and brick checkerwork in the carburetter and superheater. During the run, the decomposition of the steam abstracts heat from the fuel

bed. The blue water gas thus formed enters the carburetter where the enrichment takes place. The oil is introduced into the carburetter in the form of a fine spray by means of a needle valve. This spray of oil as it falls upon the hot checkerwork which was heated during the blast, is decomposed into gases and leaves a carbon deposit upon the brick. These oil vapors are mixed with the blue water gas and pass on to the superheater. In the superheater this mixture is again subjected to a high temperature which finishes the conversion of the oil vapors known as "fixing" into permanent gases. After condensing, scrubbing and purifying, the gases are ready for distribution.

THE PLANT

The plant consists of the following apparatus:

- 2 - 6'-6" Lowe type water gas machines, complete, manufactured by the Western Gas Construction Co., Ft. Wayne, Ind.
- 1 - Phoenix Iron Works Boiler.
- 1 - Tobin and Hanlin Manufacturing Co. Boiler.
- 1 - #7 Sturdevant Blower operated by a 35 H.P. 500 Volt General Electric motor.
- 1 - #6 Sturdevant Exhauster operated by a 15 H.P. 500 Volt Northern Motor.
- 1 - Western Gas Construction Co. Improved Tar Extractor.
- 1 - 6'-0" Station Meter
- 1 - 6'-6" Station Meter
- 1 - Small relief holder of 25,000 cu. ft. capacity.
- 1 - Large relief holder of 65,000 cu. ft. capacity.
- 1 - Large supply holder of 250,000 cu.ft. capacity.
- 1 - Large Oil tank.
- 1 - small oil tank in operating room.
- 1 - Oil Heater.
- 1 - Steam pump for circulating water in supply holder.
- 1 - Steam pump for pumping oil from large tank to small tank.

1 - Steam pump for pumping oil into carburetter.

Condensers

Scrubbers

Purifier Boxes.

Object of the Tests

The objects of the various tests were to determine the heat balance and the commercial performance of machine #1 (Plate 1) for a period of ten hours.

GENERAL METHODS OF OPERATION.

Of the two machines installed, only one is operated at any time, the other machine being shut down for repairs, this being necessary because the lining in the generator deteriorates under the action of the intense heat to which it is subjected. A machine will operate from four to eight weeks, depending upon the nature and condition of the fuel, before repairs are again necessary.

Each machine while in operation is shut down twice a day for the purpose of clinkering. In the morning between 6:00 and 7:30 the entire fire is drawn and the generator is thoroughly cleaned. Between 6:00 and 7:30 in the evening there is a second clinkering.

Instead of drawing the whole fire as is done in the morning, the fuel bed is held up by large iron bars while the clinkers are drawn out from beneath. Thus the machines are kept in continuous operation for approximately ten hours. At times of light demand upon the plant when the relief and supply holders are full, the machine is shut down. This usually occurs during the early hours of the morning.

During each complete run of ten hours the generator is charged with coke every hour and each hour is divided into "runs" and "blasts" of five and six minutes duration

respectively. The duration of these periods is varied at the discretion of the operator and depends upon the condition of the fuel bed.

The first charge in the morning is of necessity greater than the others because the generator is empty and hence the first blasts must be longer than usual to bring the fuel bed up to the proper temperature. The generator at this time is filled to only half its capacity and blasted for some time. When this has become thoroughly heated, the other half is put in and the blast continued. After about three blasts, the machine is again in normal working condition and the fuel bed is thoroughly heated through. The blasts are then made shorter as compared with the length of the runs.

There are five runs and blasts for every coking. Four of these five are "up runs"; that is, the steam is introduced below the grate and forced up through the fuel bed. Every fourth run is a "down run" in which the steam is forced through the fuel bed in the opposite direction. After each down run, the steam is again reversed for about a half minute.

From the generator the water gas passes into the carburetter, where it is mixed with the oil gas. The oil which is used in the carburetter is pumped from a large reservoir into the tank in the operating room. From

here, by means of another pump, it is forced through a heater and into the carburetter.

The flow of oil can be controlled by the operator by means of a needle valve. Approximately eighteen gallons are used for each run. Steam for the run is supplied from the electric station through an $1\frac{1}{4}$ " pipe. This is connected so as to permit an up or down run to be made.

The air for the primary and secondary blasts is supplied by the #7 Sturdevant Blower, which is operated by the 35 H.P. 500 Volt General Electric motor. From the blower to the machine the blast pipe is 16" in diameter. At the machine this pipe is tapped with a 12" pipe for the generator and an 8" pipe for the carburetter.

During the blast the steam valve is closed, the blower is running, and the stack valve and air valves are open. When changing from a blast to a run, the blower is shut off, the blast valves closed, the steam valves opened, and finally the stack valve is closed. The stack valve is closed last to allow the machine to be purged of the lean gases before turning the enriched gases into the condensing and purifying system. In changing from a run to a blast, the blower is started first after which the steam is shut off and the air valves are opened. After this is done, the stack is opened allowing time for all

of the enriched gases to have passed into the purifying system.

The operator keeps a record of the duration and number of blasts and runs, and the oil and coke consumption per run. In addition to this, readings are taken twice a day of the meters and relief holders, temperatures at the meters and outside temperature. This gives the total gas made as well as coke and oil used. These data are used by the company to determine cost of operation per 1000 cu. ft. of gas made.

GENERAL PREPARATION.

The preparations for the test consisted in arranging such apparatus whereby data could be obtained to give the results sought. That apparatus which was of the most importance and demanded considerable attention was that necessary to measure the steam and air supplied and the temperature in the various parts of the machine.

For the measurement of the steam, an orifice was used. The steam pipe supplying the machine is $1\frac{1}{4}$ " in diameter, but to eliminate irregularities in the flow as much as possible, the size of the pipe was increased from $1\frac{1}{4}$ " to 3" for a distance of about 2' on each side of the orifice. Plate II shows the general arrangement of parts. The orifice itself was only $\frac{13}{16}$ " in diameter. The drain cocks were put in for the purpose of drawing off any water which collected there while the machine was not in operation and during blast periods. Due to the fact that pressure gauges are calibrated only to 5 $\frac{1}{2}$, a mercury gauge was used to find the differential pressure. The use of the mercury gauge made it possible to read the differential pressure to within 0.1" of mercury. For the mercury gauge, hard glass tubing six feet long was used, and connections made to the pipes with stuffing boxes.

Several methods were tried for measuring the air blast, but due to mechanical arrangement of this part of the plant, the only practical means was the use of pitot tubes. Plate III shows the construction of these tubes as used in the tests. The differential head shown on the gauge is due to velocity pressure, the static pressure being equal on both sides. This is made possible by the use of a double tube, one end of which is entirely closed, while on the other end only the outer tube is closed. The space between the inner and outer tubes is opened to the air in the pipes by three slots spaced around the tube 120° apart. To both of the chambers $\frac{1}{2}$ " pipes are connected, which in turn are connected to the differential gauge. Two tubes were made; one for the primary or generator air, and one for secondary or carburettor air. These tubes were placed in the pipes on a horizontal diameter, and where there was a comparatively straight flow. Petroleum of 0.82 specific gravity in which copper oleate was dissolved served to show the pressure present. The green of the copper oleate made it easier to read the differential on the white scale.

Thermocouples were used to measure all high temperatures and for this purpose four "Bristol" couples and one nickel Nichrome couple were used. Four different

temperatures were taken with these couples, one at the outlet of the generator, one each near the bases of carburetter and superheater, and one of the exhaust at the stack. The first three couples mentioned were protected from the gases by an iron pipe closed at one end, while the couple used in the stack was held there by means of a long handle. Flexible leads were used to connect the couples to a multipolar mercury switch which was connected to a Bristol millivoltmeter. This made it possible to obtain almost simultaneous readings for all couples.

The oil used was measured by a scale which was calibrated to 0.1 inch. Each inch represented 1.82 gallons.

CALIBRATION OF APPARATUS

All the apparatus which was used during the test was calibrated over a range large enough to insure covering maximum and minimum readings in the test.

The Steam Meter

The steam measuring apparatus as described above was connected to a steam supply and condenser in the laboratory in the same way the meter was to be used on the test. Valves were arranged so as to permit the throttling of the steam on either side of the orifice. During operation, one valve was open wide and the amount of steam used controlled by the other.

The condensed steam was weighed and the time of flow taken with a stop watch. This gave pounds of steam per minute. The range of differential pressures was from 3 to 68 pounds. Curves were obtained for both the throttling of the inlet and discharge, and are shown on Plate IV. During the test the discharge was throttled, hence it was necessary to use only this curve in determining the amount of steam used.

Pitot Tubes.

In the calibration of the pitot tubes, one of the

large high pressure air tanks of the University water supply system was used as the supply reservoir. This tank was filled with air at 140 $\frac{1}{2}$ per sq.in. By reading the pressures on the tank at the beginning and end of a discharge and the temperatures of air in the tank and the discharge, it was possible to obtain the volume of air which escaped into the atmosphere. This was done with both of the pitot tubes, each being placed in the same sized pipe used in the test. In this way curves were obtained as shown in Plate V.

A standard gauge tester was used to obtain the pressure in the tank before and after the discharge. Before and after each discharge the tester would be balanced until there was neither upward nor downward motion of the piston. This was sensitive to within 0.1 $\frac{1}{2}$.

Thermocouples.

The thermocouples and the leads which were to be used on the test were calibrated against a standard Platinum-Platinum Rhodium couple. A small electric tube furnace made of porcelain and wound with nichrome ribbon was used for all calibrations. Plates VI, VII, VIII, IX, X and XI show the curves obtained from these calibrations. After the test all couples were recalibrated to determine

their constancy. No appreciable change was found. In addition to the above, a recording millivoltmeter and a Fery optical pyrometer were also calibrated because these had been brought into service after the test started.

Oil Tank

The oil tank was calibrated by draining the oil tank and noting the fall in inches per gallon. Plate XII shows the curve obtained from this.

Relief Holders

The relief holders were calibrated by measuring the outside circumference and allowing for thickness of metal. These calibrations were found to correspond to the tables used by the company.

Station Meters.

The station meters were calibrated by means of the holders, taking readings for each sheet as the gas was exhausted and correction made for temperature in each case.

METHODS PURSUED DURING TESTS.

There were three different tests made of the machine and all under the usual operating conditions. The purpose of the first or preliminary test was made to ascertain whether or not all the apparatus was in the proper condition for the test, and where special precaution would be necessary. None of the data taken on the preliminary test were used in the calculations. The preliminary test was made on Friday, February 12, 1909 from 7:30 A.M. to 6:00 P.M. The second test, or what will be called test #1, was continued Friday night and Saturday all day. Saturday morning the machine was shut down from 12:45 A.M. until 4:00 A.M. because all holders were full. The next test, or test #2 was made Tuesday, February 16, 1909 from 7:30 A.M. until 6:00 P.M. To obtain comparative results, data covering the period from 7:30 A.M. to 6:00 P.M. only, will be used from tests #1 and #2.

In obtaining the quantities of steam and air supplied to the machine, the readings of the mercury and petroleum differential gauges were taken and the time of flow of each.

Three stop watches were used to take the time. In the mercury gauge, the difference in the water columns

amounted to the same as the difference in the mercury level. This was accounted for in the determination of the steam. As the gauges held quite constant, readings were taken every minute.

Such temperatures as remained comparatively constant were read every half hour. Inlet and outlet meter temperatures, outside temperature, and temperatures in mains, blower room and generator room were included under this head. But temperatures which were of a variable nature such as found in different parts of the machine, were read twice during every run and every blast. During a part of each test, temperatures were read every half minute, those in the generator being taken by means of a recording galvanometer. The variations of these temperatures are shown on the temperature charts - Plates XIII, XIV, and XV. The radiation temperatures were also obtained by means of a thermocouple. These remained quite constant, so only a few readings were taken. To obtain the temperature of the fuel bed both from above and below, a Fery optical pyrometer was used. These temperatures were taken to determine the amount of heat remaining in the fuel bed after the day's run.

Of the steam, air, and coke supplied to the machine, there is a certain amount of moisture to be used in the

formation of blue water gas. Any excess will go through the machine as superheated steam. This excess was determined by connecting to the generator a copper coil condenser and meter. This gave the volume of moisture per cu. ft. of gas made in the generator.

As the oil was drawn from a large tank, the oil was of a uniform composition and one sample for each test was all that was necessary to be taken. The coke sample was obtained in the usual manner in such cases. As each barrowful was brought up, a small amount was taken off and the whole amount for the test divided as prescribed by the rules for boiler tests.

If time and equipment had been available, the ideal method of taking gas samples would have been to take samples of each run and each blast. This would show the effect the different conditions of fuel bed have upon the composition of the gas. But as there were six different samples taken, the above method would have necessitated the taking of thirty samples per hour, or about three hundred per day. As average conditions were all that were desired, it was sufficiently accurate to take an average sample of the day as to take a large number and average the results. Such samples were taken for both tests. Under regular operating conditions the duration of

successive runs and blasts is about the same. This gives uniformly equal volumes of steam and air supplied, and as the oil supply is always made the same, it is to be expected that the composition of the gas should be the same not only for the successive runs and blasts, but also for the same periods in successive days. In looking over the data for both tests, this will be found to be true. Although the actual volumes used differ to some extent, the proportions are approximately equal. This then will warrant the using of the compositions of the gases of the Tuesday test for the computations of the Saturday test because the samples taken Saturday were spoiled. Meters were read only at the beginning and end of the test. As the positions of the holders had changed, it was also necessary to note the difference in elevation at the time of reading. The amount of tar made was determined by pumping it from the holders and removing it from the tar extractor. Its weight, temperature and specific gravity were taken.

The ashes removed from the generator were taken for the total twenty-four hour day and half of this total taken for the day run. This was done because the removal of ashes and clinker is not as thorough in the evening as in the morning.

ANALYSES.

After the tests were completed, any samples which were taken were tested by standard methods. For the six different samples taken at each test, the Hempel Apparatus was used. New solutions were made up, and when any of them showed signs of becoming saturated, they were rejected and new ones used. Duplicate analyses were made until checks were obtained.

For the determination of the heating values of the coke, ashes, oil and tar, a Mahler Bomb calorimeter was used. Great care was used with this apparatus and duplicate checks were obtained on all samples. Another sample of oil was distilled at different temperatures, and the percent of the total found for each temperature taken.

The oil used for the "enriching" must of necessity be rich in hydrocarbons; hence a large percent of the oil is deposited as carbon in the carburetter when "cracked". To determine this, a small cartridge, shown in Plate XVI was put into an electric furnace and with the syringe a known amount of oil was put into the cartridge and vaporized at a high temperature. The carbon was deposited and by the difference in weight before and after the test, the actual weight of carbon was found.

This same cartridge was used to determine the relative amounts of heat necessary to vaporize water and oil as shown in Plate XVII. Equal volumes of oil or water were injected into the cartridge with the syringe and the drop in temperature noted for each by means of a 12" Pt. - Pt.Rd. couple and a potentiometer set. The calibration for this couple is shown on Plate X-A.

The oil curve for equal weight obtained from the experimental curve for equal volume is also shown. These curves are parabolic in form, sloping upward and to the right while that for the water is a straight line sloping downward and to the right. Theoretically this should slope upward as the oil curves do, showing an increased drop in temperature as the temperature of the furnace is increased. It will be noticed that in the calculation used to find the heat necessary to crack the oil in the carburetter, it was assumed that the slope was upward and to the right. The Monel metal used for the cartridge has a high coefficient of heat conductivity and due to this fact at the higher temperatures the flow of heat from the furnace into the cartridge is more rapid and hence the drop in temperature is less than theoretically would be expected.

CALCULATION

For Test #1.

Saturday, February 13th, 1909

7:30 A.M. to 6:00 P.M.

DATA

Test of Saturday, February 13th, 1909

7:30 A.M. to 6:00 P.M.

Primary air blast as measured		534,130 feet
Primary air blast temperature		57.4° F.
Secondary air blast as measured		163,210 feet
Secondary air blast temperature		57.4° F.
Steam Consumption		
(Dry Steam	7808.3#	
(Moisture	<u>123.9#</u>	7932.2#
Quality of Steam	(During blast 97.8%	
	(During run 98.4%	
Wet coke used		
(Dry coke	10406#	
(Moisture	<u>1819#</u>	12225 #
(Carbon content	8950#	
Wet ashes recovered		
(Dry ashes	989.6#	
(Moisture	<u>73.4#</u>	1063 #
Total Oil Consumption		885.03 Gal. or 6425.3 #
Oil Temperature		123.4° F.
Tar Recovered		670#
Purified Gas Made		228.900 feet.

Heating Values

Coke, per pound	12983
Ashes per pound	4762
Oil per gallon	142100
Tar per pound	16266

Mean relative humidity - - 60%

CALCULATIONS

Test of Saturday, February 13th, 1909

7:30 A.M. to 6:00 P.M.

From the analysis of generator blast gas, for every 100 cubic feet of blast gas, there are

9.21	cubic feet	CO ₂
1.62	" "	O ₂
13.60	" "	CO
75.66	" "	N ₂

Weight of CO₂ per 100 ft. of gas = $9.12 \times 1.98 = 18.08$ oz.

Weight of CO per 100 ft. of gas = $13.60 \times 1.26 = 17.13$ oz.

Wt. of C in CO₂ " " " " " = $12/44 \times 18.08 = 4.93$ oz.

Wt. of C in CO " " " " " = $12/28 \times 17.13 = \underline{7.34}$ oz.

Total C per 100 ft. of gas 12.27 oz.

In 9.12 feet of CO₂ there are 9.12 feet O₂

In 13.60 " " CO " " 13.6/2 " O₂

Total O₂ per 100 ft. of gas $9.12 + 1.62 + 6.8 = 17.54$ feet

Equivalent air per 100 feet gas = $17.54/.208 = 84.3$ feet

Thus in 100 feet of gas, 84.3 feet of air are required to burn the 12.27 oz. C.

The air required per pound of C is given by

$$84.3/x = 12.27/16 \text{ where } x = 110 \text{ feet per lb. C.}$$

From the Log Data, 534,130 feet of air were used on Saturday in the primary air blast.

With 110 feet of air per pound of C -

the weight of carbon burned in blasting during day =
 $534130/110 = 4855.7\#$

the actual weight of carbon consumed during day was
 $.7318 \times 12227 = 8947.7\#$

the carbon left for use during "run" is
 $8947.7 - 4855.7 = 4092.0\#$

The analysis of generator gas during "run" shows that for every 100 feet of gas there are

2.96	feet of	CO ₂
1.53	" "	O ₂
43.44	" "	CO
39.31	" "	H ₂
12.76	" "	N ₂

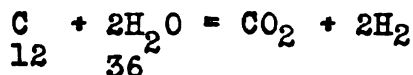
In every 100 ft. of gas there are (from CO₂)

$2.96 \times 1.98 \times 12/44 = 1.598 \text{ oz. C}$

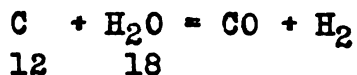
In every 100 ft. of gas there are (from CO)

$43.44 \times 1.26 \times 12/28 = 23.44 \text{ oz. C}$

Total = 25.04 oz. C



From the above equation, the ounces of steam decomposed to CO_2 are given by $1.598/12 = x/36$ where $x = 4.77$ oz.



From this equation, the ounces of steam decomposed to CO are given by $23.44/12 = x/18$ where $x = 35.20$ oz.
Total steam thus decomposed per 100 feet of gas = 39.97 oz.

The weight of steam consumed during the Saturday test was
7932.2~~f~~

The weight of carbon required during "run" is given by
 $25.04/39.97 = x/7932.2$ where $x = 4970~~f~~$

This shows that plenty of air was forced in the primary blast, since, from above, the carbon left for the run was 4092~~f~~

From the analysis, in every 100 feet of generator blast gas there are -- 9.12 feet of CO_2
1.62 " " O_2
13.60 " " CO
75.66 " " N_2

and in this there are

$$\begin{array}{rcl} 9.12 \times 1.98 \times 12/44 & = & 4.92 \text{ oz. C} \\ 13.60 \times 1.26 \times 12/28 & = & \underline{7.35 \text{ oz. C}} \\ \text{Total} & & 12.27 \text{ oz. C} \end{array}$$

Also

$$\begin{aligned}
 9.12 \times 1.98 \times 32/44 &= 13.11 \text{ oz. } O_2 \\
 1.62 \times 1.44 &= 2.33 \text{ oz. } O_2 \\
 13.60 \times 1.26 \times 16/28 &= \underline{9.79 \text{ oz. } O_2} \\
 \text{Total} & 25.23 \text{ oz. } O_2
 \end{aligned}$$

Weight of air corresponding to 25.23 oz. O_2 =

$$25.23 / .2305 = 109.54 \text{ oz.}$$

Weight of air per ounce of C present $109.54 / 12.27 = 8.94 \text{ oz.}$

In a similar manner, from the analysis of the superheater blast gas, there are in every 100 feet of gas

$$\begin{aligned}
 &14.61 \text{ feet of } CO_2 \\
 &0.53 \quad " \quad " \quad O_2 \\
 &7.22 \quad " \quad " \quad CO \\
 &77.64 \quad " \quad " \quad N_2
 \end{aligned}$$

and in this there are

$$\begin{aligned}
 14.61 \times 1.98 \times 12/44 &= 7.9 \text{ oz. C} \\
 7.22 \times 1.26 \times 12/28 &= \underline{3.89 \text{ oz. C}} \\
 \text{Total} & 11.79 \text{ oz. C}
 \end{aligned}$$

Also

$$\begin{aligned}
 14.61 \times 1.98 \times 32/44 &= 21.00 \text{ oz. } O_2 \\
 0.53 \times 1.44 &= 0.76 \text{ oz. } O_2 \\
 7.22 \times 1.26 \times 16/28 &= \underline{5.20 \text{ oz. } O_2} \\
 \text{Total} & 26.96 \text{ oz. } O_2
 \end{aligned}$$

Weight of air corresponding to 26.96 oz. O_2 =

$$26.96 / .2305 = 116.86 \text{ oz.}$$

Weight of air per ounce of C present = $116.86 / 11.79 =$

$$9.91 \text{ oz.}$$

Therefore, the weight of air supplied by secondary blast per ounce of C must be $9.91 - 8.94 = 0.97 \text{ oz.}$

In 100 feet of generator blast gas there are 12.27 oz. C

Therefore the secondary air required per 100 feet of gas is

$$12.27 \times 0.97 = 12.16 \text{ oz.} \quad \text{or}$$

$$12.16 / 1.293 = 9.4 \text{ feet of air}$$

Now from the generator blast gas,

$$8.94 \text{ oz. air per oz. C} = 8.94 \text{ air per C}$$

and from the calculations above, the weight of carbon burned on Saturday per day during the blast was 4855.7.

Since 1 air is equivalent to $16 / 1.293 = 12.36$ feet of air, and knowing the volume of primary blast to be (as measured) 534,130 feet,

$$\text{we have } 534,130 / 8.94 \times 12.36 = 4850 \text{ of C burned.}$$

This checks the 4855.7 above.

In burning 13.6 feet of CO to CO_2 , $13.6 / 2$ or 6.8 feet of O_2 are required which corresponds to

$$6.8 / .208 = 32.63 \text{ feet of air}$$

Thus to burn the CO in 100 feet of generator blast gas,
32.63 feet of air are necessary.

From the primary blast analysis we find 8.94 feet
of air necessary for 1 oz. C.

The weight of C present in 100 feet of gas is 12.27 oz.

Total air necessary for 100 ft. of gas = $12.27 \times 8.94 / 1.293$
= 84.6 feet.

or for every 84.6 feet of primary air supplied, 100 feet
of generator blast gas were made.

Thus the volume of gases leaving generator during blast =

$$(534,130 / 84.7) \times 100 = 630,000 \text{ feet.}$$

The free air in 100 feet of generator blast gas =

$$1.62 / .208 = 7.8 \text{ feet.}$$

Net air required in secondary blast to burn CO in 100 feet
of gas = $32.63 - 7.8 = 24.83$ feet.

Thus the necessary air in secondary blast is

$$630,000 \times 24.83 / 100 = 156,430 \text{ feet.}$$

This checks fairly close the actual volume of secondary
air blast for Saturday as measured, 163,210 feet.

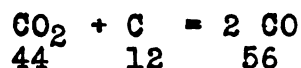
The oxygen of the secondary air combines with the
CO of the gas to form CO_2 , the volume of CO_2 formed being
the same as that of the original CO. The only increase in
volume is due to the N_2 which accompanys the O_2 .

This increase is $156,430 \times .792 = 124,000$ feet.

Thus the actual volume of superheater gas is

$$630,000 + 124,000 = 754,000 \text{ feet.}$$

Due to the oil carbon deposit in the carburetter, some of the CO_2 is reduced to CO.



or (from the analysis) 7.22 vol. CO is equivalent to 3.61

$$\text{vol. CO}_2 \quad 1 \text{ oz. CO}_2 + 12/44 \text{ oz. C} = 56/44 \text{ oz. CO}$$

$$3.61 \text{ ft. CO}_2 = 3.61 \times 1.98 = 7.15 \text{ oz. CO}_2$$

Therefore $7.15 \times 12/44 = 1.95$ oz. C are required per 100 feet of gas.

The amount of carbon residue will theoretically be

$$754,000 \times 1.95/100 \times 16 = 918.9\frac{1}{2}$$

$$\begin{array}{l} \text{The actual deposit as determined, was } 6425.3\frac{1}{2} \times \\ .2295 = 1475\frac{1}{2} \end{array}$$

The excess deposit of oil carbon, $556.1\frac{1}{2}$ either remained on the brickwork or was burned out in blasting. During the beginning of each blast, a red flame was noticeable in the stack for some time, denoting burning out of carbon.

In the reduction of CO_2 to CO, the volume of the CO_2 so burned will be doubled.



For every 100 ft. of superheater blast gas, there will be an increase of 3.61 feet.

Total increase due to reduction of CO_2 by C from oil deposit = $754,000 \times 3.61/100 = 27,200$ feet.

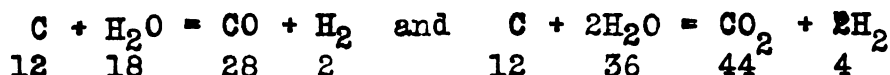
Volume of gases escaping through stack valve =

754000

27200

781200 feet.

During the run, the reactions in the generator take place according to the equations



On a basis of 12 Kg carbon, the heat absorbed			
(with the reactions taking place at 0°C) would be			
for the formation of CO		for the formation of CO_2	
58060	Kg calories for H_2O	116120	Kg calories for H_2O
- 29160	" " " CO	- 97200	" " " CO_2
= 28900	" " "	= 18920	" " "

Since from the temperature readings taken of the coke bed, we find the reactions taking place at 1220°C rather than 0°C , these values must be corrected. The true value is obtained by subtracting from the heat of absorption at 0°C the heat in the reagents, and adding the heat in the products.

The specific heat for carbon at temperatures over 1000°C is $(0.5 - 120/t)$

Thus the heat in 12 KgC is $12(0.5 - 120/1220) 1220 = 5870$ Kg calories.

The specific heat for H_2O is given by

$$(0.34 \times t + .00015 t^2)$$

Since 1 molecular weight of any gas in Kg is equal to 22.22 cu. meters, the heat in 18 Kg H_2O at 1220°C is $22.22(0.34 \times 1120 + .00015 \times 1120^2) = 10420$ Kg calories.

Heat in reagents = $5870 + 10420 = 16290$ Kg calories.

The specific heat for CO and H_2 is given by

$$(0.303t + .000027 t^2)$$

The heat in 28 Kg CO and 2 Kg N_2 is therefore

$$44.44 (0.303 \times 1220 + 0.000027 \times 1220^2) = 18200 \text{ Kg calories}$$

Actual heat of absorption at 1220°C is therefore

$$28900 - 16290 + 18200 = 30810 \text{ Kg calories} =$$

$$4645 \text{ BTU per } ^{\circ}\text{C}.$$

In a similar manner, the heat in the reagents in the formation of CO_2 is 38450 Kg calories and the heat in the products is 35500 Kg calories. The actual heat of absorption at 1220° is therefore

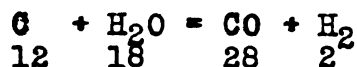
$$18920 - 38450 + 35500 = 15970 \text{ Kg calories} =$$

$$2395 \text{ BTU per } ^{\circ}\text{C}.$$

From the analysis of the generator gas during the "run" we find $2.96\% \text{ CO}_2$

and $43.44\% \text{ CO}$

Thus for every 100 feet of gas there are 43.44 feet of CO
or $43.44 \times 1.26/16 = 3.42\frac{7}{8} \text{ CO}$



The weight of steam necessary to form $3.42\frac{7}{8} \text{ CO}$ is given
by $28/3.42 = 18/x$ $x = 2.2\frac{7}{8} \text{ steam per 100 ft. gas.}$

In the same way, for every 100 feet of gas, there are

$$2.96 \times 1.98/16 = 0.366\frac{7}{8} \text{ CO}_2$$

and the steam necessary for the formation of the CO_2 in
100 feet of gas is given by $44/0.366 = 36/x$

$$\text{and } x = .2995\frac{7}{8}$$

From the actual moisture determination, there are present
 $0.914\frac{7}{8} \text{ water per 100 feet of gas.}$

The weight of vapor in the saturated gas at 106° F is
 $0.3377\frac{7}{8} \text{ per 100 feet of gas.}$

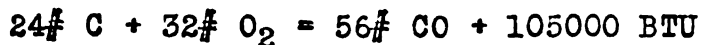
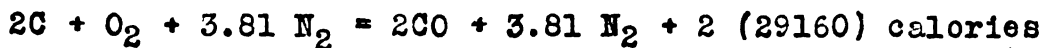
The total moisture thus present is

$$2.2 + .2995 + 0.3377 + 0.914 = 3.751\frac{7}{8} \text{ per 100 ft. of gas.}$$

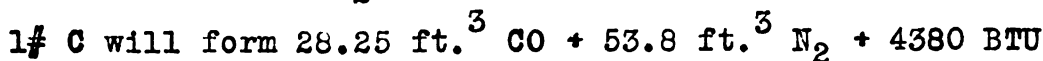
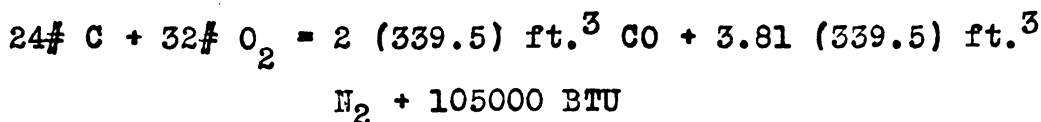
Since the total steam consumption for the Saturday test was
 $7932.2\frac{7}{8}$, the blue water gas made during the test was

$$7932.2 \times 100/3.751 = 211,500 \text{ feet.}$$

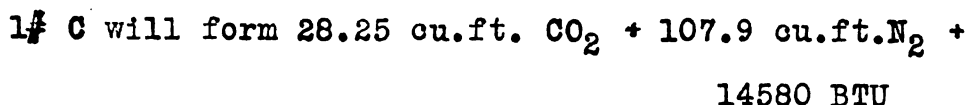
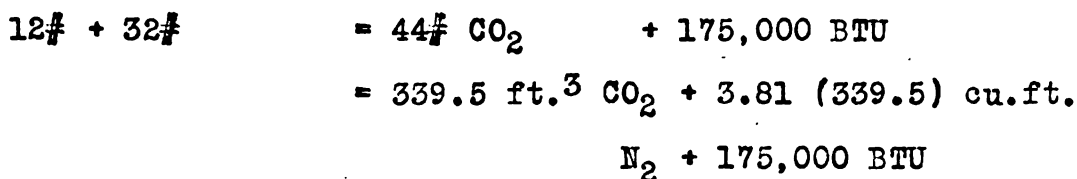
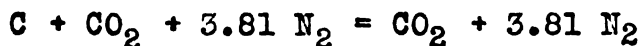
With the blasting of the coke



Since 1 molecular weight of gas in pounds is equivalent to
339.5 feet of gas



Similarly



The volume of blast gases leaving the generator is 630,000 feet. Heat liberated in the generator from formation of CO_2 is

$$\frac{.0912 \times 630,000 \times 1.98 \times 12 \times 14580}{16 \times 44} = 28,250,000 \text{ BTU}$$

Heat liberated from formation of CO is

$$\frac{.1360 \times 630,000 \times 1.26 \times 12 \times 4380}{16 \times 28} = 12,680,000 \text{ BTU}$$

$$\text{Total} \quad 40,930,000 \text{ BTU}$$

Volume of CO_2 leaving the generator is

$$.0912 \times 630,000 = 57,500 \text{ feet}$$

Sensible heat leaving in CO_2 at 1600° F is

$$57500 (.00581 + .00000345 \times 1600) 1600 = 1,042,000 \text{ BTU}$$

The volume of CO , O_2 , and N_2 leaving the generator is

$$0.9088 \times 630,000 = 572,500 \text{ feet}$$

The sensible heat leaving the generator in the above gases at 1600° F is

$$572,500 (0.00475 + 0.00000847 \times 1600) 1600 = 16,780,000 \text{ BTU}$$

Total sensible heat leaving generator in gases is therefore

$$17,822,000 \text{ BTU}$$

Available heat left in coke, $40,930,000 - 17,822,000$

$$= 23,108,000 \text{ BTU}$$

Generator gas made was 211,500 feet.

$$\text{Pounds of C present in CO} = \frac{0.4344 \times 211500 \times 1.26 \times 12}{16 \times 28} =$$

$$3100\frac{1}{2}$$

$$\text{Pounds of C present in CO}_2 = \frac{0.296 \times 211500 \times 1.98 \times 12}{16 \times 44} =$$

$$210.5\frac{1}{2}$$

Heat absorbed from coke by CO is

$$4645 \times 3100 = 14,400,000 \text{ BTU}$$

Heat absorbed by CO_2 is

$$2395 \times 210.5 = 505,000 \text{ BTU}$$

Total heat absorbed 14,905,000 BTU

The values 4645 and 2395 are the corrected heats of absorption as determined above.

The radiation and convection losses for the machine were calculated by extrapolation from the tables given in Carpenter's "Heating and Ventilating Buildings" pages 64 and 65. For the radiation determination, the average excess temperature of the generator surface as determined from thermocouple readings was 219° F. The surface area as computed is 332 square feet. The constant K was taken as 3.30. The radiation loss per square foot per hour was found to be 258 BTU. For a ten hour day this amounts to 856,000 BTU. Similarly for convection, the constant K' was found to be 2.16 and the convention loss 166 BTU per square foot per hour. For the same length of time, the convection loss was 551,000 BTU.

Thus the total radiation and convection loss for the generator as computed was 1,407,000 BTU.

Heat was necessary to vaporize and superheat the free moisture in the entering steam.

With the latent heat of vaporization as 965 BTU per #, the heat of vaporization will be $123.9 \times 965 = 119,200$ BTU

The heat necessary to superheat this steam to 1600° F

will be $123.9 \times .48 \times 1400 =$

83,200 BTU

Total

202,400 BTU

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Thus the total radiation and convection loss for the generator as computed was 1,407,000 BTU.

Heat was necessary to vaporize and superheat the free moisture in the entering steam.

With the latent heat of vaporization as 965 BTU per #, the heat of vaporization will be $123.9 \times 965 = 119,200$ BTU

The heat necessary to superheat this steam to 1600° F

will be $123.9 \times .48 \times 1400 =$

83,200 BTU

Total

202,400 BTU

Heat was necessary to vaporize and superheat the moisture entering with the wet coke as snow and ice. This moisture amounted to 1819#. Taking the total heat in steam as 1146 BTU per #, the heat loss to 212° F was

$$1819 \times 1146 = 2,085,000 \text{ BTU}$$

$$\text{Superheat to } 1600^\circ \text{ F was } 1819 \times .48 \times 1400 = \underline{1,222,000 \text{ BTU}}$$

$$\text{Total} \quad 3,307,000 \text{ BTU}$$

The moisture determination showed 0.914# of free moisture or steam per 100 feet of gas.

$$\text{The total amount of moisture present was } \frac{.914 \times 211500}{100} = 1930\#$$

The heat necessary to superheat 1930# from 212° F to 1600° F was taken as $1930 \times .48 \times 1400 = 1,295,000 \text{ BTU}$

After the last run is made, a large amount of heat was left in the coke and in the brick lining. The volume of this brick lining above the grate was found to be 130 cubic feet, and with the weight of brick as 140# per cubic foot, the weight is 18200#. The specific heat of brick was taken as 0.19. The mean of the inside and outside temperatures of the lining was 700° F. The heat thus left stored in the brick was $18200 \times 0.19 \times 700 = 2,420,000 \text{ BTU}$. Since, however, the mean temperature of the brick at the beginning of the test was not 32° F but about 400°, the net heat left after the test was $2,420,000 - (18200 \times 0.19 \times 500) = 690,000 \text{ BTU}$.

Also, after the last run, a considerable amount of heat was left in the fuel bed. The volume occupied by this remaining fuel was about 58 cubic feet. The weight of dry ashes recovered was 989.6#, of which 306# was carbon and 683.6# was ash. With 30# of fuel per cubic foot (as determined from measurements) the total weight of remaining fuel bed was 1740#. The weight of coke present was $1740 - 989.6 = 750.4\#$. Of this, 645# is carbon and 57.4# is ash. Thus the total carbon present is 951# in which the stored heat is $951 (0.5 - 120/1110) 1110 \times 1.8 = 748,000$ BTU. The total ash present is 741# in which the heat stored is $741 \times 0.2 \times 2000 = 296,000$ BTU. The total heat stored in the fuel bed is 1,044,000 BTU.

Due to the presence of moisture in the air blast, heat was required to vaporize and superheat such moisture. The mean humidity was 60% and the air temperature was approximately 58° F. From Kent's "Mechanical Engineer's Pocket Book" page 484, the weight of moisture per cubic foot of air at 58° F is 0.000754#. The water thus introduced into the generator is $534,130 \times .000754 \times .60 = 241.5\#$. Heat required to raise the temperature of 241.5# of water from 58° F to 212° F

	= 37,200 BTU
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Heat required to vaporize same	= 233,000 BTU
Heat required to superheat same to 1600° F	= 162,000 BTU
Total	432,200 BTU

Also, after the last run, a considerable amount of heat was left in the fuel bed. The volume occupied by this remaining fuel was about 58 cubic feet. The weight of dry ashes recovered was 989.6#, of which 306# was carbon and 683.6# was ash. With 30# of fuel per cubic foot (as determined from measurements) the total weight of remaining fuel bed was 1740#. The weight of coke present was $1740 - 989.6 = 750.4\#$. Of this, 645# is carbon and 57.4# is ash. Thus the total carbon present is 951# in which the stored heat is $951 (0.5 - 120/1110) 1110 \times 1.8 = 748,000$ BTU. The total ash present is 741# in which the heat stored is $741 \times 0.2 \times 2000 = 296,000$ BTU. The total heat stored in the fuel bed is 1,044,000 BTU.

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	-	
		= 37,200 BTU

Heat required to vaporize same		= 233,000 BTU
Heat required to superheat same to 1600° F		- 162,000 BTU
Total		432,200 BTU

A considerable amount of heat enters the generator as sensible heat in the primary air. With the specific heat of air as 0.24 and the temperature above freezing as $58 - 32 = 26^{\circ} \text{ F}$, this quantity of heat amounted to $534,130 \times 0.24 \times 26 = 3,330,000 \text{ BTU}$.

The heat entering with the moisture of the primary air is $241.5 \times .000754 \times .60 \times 26 = 6280 \text{ BTU}$.

Heat is required to superheat the total dry steam introduced to 1600° F in order to permit of the chemical action taking place. This heat amounts to

$$7808.3 \times .48 \times 1400 = 5,250,000 \text{ BTU}.$$

The heat leaving the generator as sensible heat in the blue water gas is distributed as follows:

CO_2

$$\frac{211500 \times .0296}{35.3} (0.37 + .00022 \times 900) 900 \times 1.8 \times 2.204 = 236,000 \text{ BTU}$$

$\text{CO}, \text{H}_2, \text{N}_2 \text{ and } \text{O}_2$

$$\frac{211500 \times .9704}{35.3} (0.303 + .000027 \times 900) 900 \times 1.8 \times 2.204 = 6,300,000 \text{ BTU}$$

$$\text{Total} \quad 6,536,000 \text{ BTU}$$

From the above we find that the heat introduced into the generator during the day was distributed as follows:

Heat stored in fuel bed during blast	40,930,000 BTU
Heat entering with dry steam	8,950,000 "
Heat entering with dry air	3,330,000 "
Heat entering with steam moisture	26,200 "
Heat entering with air moisture	6,280 "

Total	53,242,480 BTU
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This amount of heat introduced into the generator was absorbed or dissipated in the following manner:

Heat leaving as sensible heat in blast gases	17,822,000 BTU
Heat required for production of blue water gas	14,905,000 "
Heat leaving as sensible heat in blue water gas	6,536,000 "
Heat required to superheat dry steam	5,250,000 "
Heat required to vaporize and superheat coke moisture	3,307,000 "
Heat lost as radiation and convection	1,407,000 "
Heat required to superheat moisture in gas	1,295,000 "
Heat remaining in fuel bed	1,044,000 "
Heat remaining in brick lining	690,000 "
Heat required to vaporize and superheat blast moisture	432,200 "
Heat required to vaporize and superheat steam moisture	202,400 "
Heat unaccounted for	351,880 "
Total	53,242,480 BTU

Generator efficiency =

$$\frac{14,905,000 + 6,536,000}{53,242,480} = 40.3\%$$

CALCULATIONS FOR CARBURETTER
AND SUPERHEATER

Test of Saturday, February 13th, 1909

7:30 A.M. to 6:00 P.M.

CALCULATIONS FOR CARBURETTER & SUPERHEATER

Test of Saturday, February 13th, 1909

7:30 A.M. to 6:00 P.M.

The heat supplied will be as follows:

Sensible heat in the blast gases

Sensible heat in the blue water gas

Sensible heat in the secondary air

Sensible heat in the oil

Sensible heat in the moisture of the secondary air

Heat liberated by the burning of CO.

The heat introduced as above will be absorbed, lost or dissipated as follows:

Heat necessary to crack oil

Heat absorbed by reduction of CO_2 to CO by oil deposit

Sensible heat in escaping stack gases

Sensible heat in unpurified carburetted water gas leaving the machine.

Heat necessary to vaporize and superheat the moisture in the secondary air.

Heat lost as radiation and convection

Heat left in brickwork after last run.

As determined before, the sensible heat supplied in the blast gases was 17,822,000 BTU and in the blue water gas

was 6,536,000 BTU.

The sensible heat in the secondary air was

$$163,210 (.00475 + .00000847 \times 26)26 = 21,190 \text{ BTU.}$$

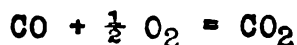
Taking specific heat of the oil as 0.472, the heat introduced as sensible heat in the oil was

$$6425.3 \times 123.4 \times 0.472 = 375,000 \text{ BTU.}$$

The sensible heat in the moisture of the secondary air was

$$163,210 \times .000754 \times .60 \times 26 = 1920 \text{ BTU.}$$

The CO in the entering blast gases is burned by the admission of secondary air according to the equation



At 0° C, the heat liberated by this reaction is

97,200 - 29,160 = 68,020 KG calories per 22.22 cubic meters. Since the reaction takes place at 1600° F or about 900° C, we must add to the above value the sensible heat of the products and subtract the sensible heat of the reagents.

The sensible heat of the reagents is

$$33.33 (.303 + .000027 \times 900) 900 = 9280 \text{ Kg calories.}$$

The sensible heat of the product is

$$22.22 (.37 + .00022 \times 900) 900 = 11380 \text{ Kg calories}$$

The corrected value of heat liberated is therefore

$$68020 - 9820 + 11380 = 70580 \text{ Kg calories per 22.22}$$

cubic meters or 357 BTU per cubic foot.

The total heat thus liberated by combustion was

$$630,000 \times .1360 \times 357 = 30,600,000 \text{ BTU.}$$

The volume of the checkerwork brick in the carburettor was determined as 123 cubic feet. The weight of this brickwork amounts to $123 \times 140 = 17,200\frac{1}{2}$.

The heat left stored here was $17,200 \times 0.19 \times 1600 = 5,220,000 \text{ BTU}$. The volume of the checkerwork brick in the superheater was determined to be 171 cubic feet, and the weight of the same $171 \times 140 = 23,950\frac{1}{2}$. The heat left stored here was

$$23,950 \times 0.19 \times 1400 = 6,350,000 \text{ BTU}$$

The volume of the lining of the carburettor was computed from measurements to be 279 cubic feet. With the average temperature of the lining as 890° F , the heat left stored here was

$$279 \times 140 \times 0.19 \times 890 = 6,610,000 \text{ BTU}$$

Similarly the heat left stored in the brick lining of the superheater was

$$339 \times 140 \times 0.19 \times 780 = 7,040,000 \text{ BTU.}$$

The total heat thus stored in the brickwork was

$$25,220,000 \text{ BTU}$$

No correction has to be made here for bringing the machines into operation cold, for thermocouple readings

showed the temperatures of carburetter and superheater to remain practically constant during the time taken for clinkering and cleaning.

Assuming that all the CO of the entering blast gas is burned to CO₂, the actual net O₂ necessary as shown from the analysis of generator blast gas would be $13.6/2 - 1.62 = 5.18$ feet of O₂ per 100 feet of gas. 5.18 feet of O₂ represents 24.9 feet of air in which there are 19.70 feet of N₂. Thus, on burning the CO in 100 feet of gas by the addition of 24.9 feet of air, the resultant volume is $9.12 + 13.60 + 75.66 + 19.70 = 118.08$ feet. The percentage of CO₂ now present after burning is

$$\frac{(13.60 + 9.12)}{118.08} = 19.21\%$$

Thus, for every 100 feet of gas burned, there results 19.21 feet of CO₂ or for every 100 feet of gas burned there are required $19.21 \times 1.98 \times 12/44 = 10.35$ oz.C. From the analysis of superheater blast gas, there are present 11.79 oz. C per 100 feet of gas. The carbon therefore picked up from the checkerwork brick per 100 feet of gas must be $11.79 - 10.35 = 1.44$ oz. If completely burned, the actual volume of blast gases leaving the superheater would be $630,000/100 \times 1.18 = 745,000$ feet.

The weight of oil deposit carbon picked up from the brick was therefore

$$745,000/100 \times 1.44/16 = 670\frac{1}{2}$$

The actual amount of deposit carbon present in the oil as determined was 22.95%.

The carbon deposited was therefore

$$6425.3 \times .2295 = 1475\frac{1}{2}$$

The remainder $1475 - 670$ or $805\frac{1}{2}$ was left on the brick.

According to the reaction



$97000 - 59320 = 37680$ Kg calories were absorbed per 12 Kg of carbon.

The total heat thus absorbed was

$$\frac{3140 \times 670 \times 3.96}{12 \times 2.204} = 3,775,000 \text{ BTU}$$

The analysis of superheater blast gas shows that for every 100 feet of gas there are

14.61 feet CO_2

0.53 " O_2

7.22 " CO

77.64 " N_2

The sensible heat in the CO_2 is

$$.1128 \times 14.61 (.37 + .00022 \times 780) 780 = 695 \text{ BTU}$$

and in the other gases

$$.1128 \times 85.39 (.303 + .000027 \times 780) 780 = 242 \text{ BTU}$$

Total

937 BTU

The heat thus lost as sensible heat in the escaping blast gases was

$$781,200/100 \times 937 = 7,310,000 \text{ BTU}$$

The radiation and convection losses for carburettor and superheater amounted to 2,640,000 BTU.

The weight of the moisture in the secondary air was $163,210 \times .000754 \times .60 = 73.9\frac{1}{2}$

The heat required to vaporize and superheat this was 142,280 BTU.

The heat necessary to raise $1\frac{1}{2}$ of water from 123° F to 212° F , convert it into steam and superheat it to 1600° F is 1726 BTU.

From Plate XVII the ratio of the gross heat of oil to that of water at 1600° F is found to be 102/188. The heat that was therefore necessary to crack the oil was $6425.3 \times 1726 \times 102/188 = 6,010,000 \text{ BTU}$

The analysis of the carburetted gas leaving the superheater shows that for every 100 feet there are

		whose specific heats are
2.43 feet	CO_2	(0.37 + .00022 t)
13.07 "	C_2H_4	(0.46 + .0003 t)
19.10 "	C_2H_6	(0.38 + .00022 t)
0.17 "	O_2	
32.67 "	CO	
26.43 "	H_2	65.40(0.303 + .000027 t)
6.13 "	N_2	

The sum of the products of each constituent above multiplied by its specific heat and rise in temperature from 0° C to 780° or 1400° F shows that the sensible heat in 100 feet of gas was 3709.8 BTU. The total heat thus leaving as sensible heat in the unpurified carburetted water gas was

$$(270,000/100) \times 3709.8 = 10,000,000 \text{ BTU}$$

Referring to an article by R. Ross and J. P. Leather in the "London Journal of Gas Lighting", June 19, 1906, and to "Liquid and Gaseous Fuels" by V. B. Lewes, the amount of oil gas made per liter was taken as 614 liters. This is the same as 66.3 feet of oil gas per gallon. The total oil gas made per day was then $885.03 \times 66.3 = 58,600$ feet. Since the blue water gas amounted to 211,500 feet, the unpurified carburetted gas made was $211,500 + 58,600 = 270,100$ feet. The free volume of carburetter and superheater was determined as 3260 cubic feet. The gas lost in "purging" the machine amounted to $50 \times 3260 = 163,000$ feet. Correcting this value to 60° F and subtracting it, we have $270,100 - 41,100 = 229,100$ feet which checks the purified gas 228,900 as measured.

Thus the heat entering the carburetter was distributed as follows:

Heat liberated by burning of CO	30,600,000 BTU
Sensible heat in blast bases	17,822,000 "
Sensible heat in blue water gas	6,536,000 "
Sensible heat in oil	375,000 "
Sensible heat in secondary air	21,190 "
Sensible heat in moisture of air	1,920 "
Total	55,356,110 "

This amount of heat was dissipated as follows:

Heat left stored in brickwork	25,220,000 BTU
Sensible heat in carburetted gas	10,000,000 "
Sensible heat in blast gases	7,310,000 "
Heat necessary to "crack" oil	6,010,000 "
Heat absorbed by reduction of CO ₂	3,775,000 "
Heat lost by radiation and convection	2,640,000 "
Heat required to superheat air moisture	142,280 "
Heat unaccounted for	258,830 "
Total	55,356,110 BTU

Carburetter Efficiency =

$$\frac{10,000,000 + 6,010,000}{55,356,110} = 29.0\%$$

DATA

Test of Tuesday, February 16th, 1909

7:30 A.M. to 6:00 P.M.

DATA

Test of Tuesday, February 16th, 1909

7:30 A.M. to 6:00 P.M.

Primary air blast as measured		537,490 feet
Primary air blast temperature		55.4° F.
Secondary air blast as measured		133,880 feet
Secondary air blast temperature		55.4° F.
Steam consumption		
(Dry steam	7376.0#	
(Moisture	<u>120.0#</u>	7496.0#
Quality of steam during blast	97.8%	
Quality of steam during run	98.4%	
Wet coke used		
(Dry coke	11,102#	
(Moisture	895#	
(Carbon content	<u>9,633#</u>	11997 #
Wet Ashes recovered		
(Dry ashes	986.6#	
(Moisture	<u>73.4#</u>	1185 #
Total Oil Consumption		796.1 gal. or 5779.7#
Oil Temperature		119.1° F.
Tar Recovered		670#
Purified Gas Made		215800 ft.

Heating Values

Coke per pound	12815
Ashes per pound	1842
Oil per gallon	141400
Tar per pound	16266
Mean relative humidity	50%

Following the same method as outlined for the Saturday test, the amount of carbon burned during the blast is found to have been

$$537,490/110 = 4886.3\frac{1}{2}$$

Actual weight of carbon consumed was 9633 $\frac{1}{2}$

Carbon left for production of blue water gas 4746.7 $\frac{1}{2}$

The amount of carbon required for blue water gas is given by $25.04/39.97 = x/7946$. Thus $x = 4700\frac{1}{2}$ which checks closely the value of 4746.7 $\frac{1}{2}$ given above.

The volume of blast gases leaving the generator was $(537,490/84.7) \times 100 = 635,000$ feet.

The necessary air in the secondary blast was

$$(635,000/100) \times 24.83 = 157,670 \text{ feet.}$$

The actual volume of secondary blast as measured was only 133,880 feet, showing that not enough secondary air was admitted for efficient operation. An inspection of the Log Data will show that for the first two or three hours on Tuesday morning, very much less secondary air was admitted than for the corresponding blasts on Saturday. The statement that the secondary valve was not open wide enough is borne out by the fact that, especially at the beginning of the blasts, sometimes blue and sometimes luminous flames appeared and remained for some time above the stack valve, due to the combustion of the CO and the

oil deposit.

With the addition of secondary air, the increase in volume is due only to the N_2 entering. This increase is equal to $133,880 \times .792 = 106000$ feet. The actual volume of superheater gases is now

$$635,000 + 106,000 = 741,000 \text{ feet.}$$

The amount of carbon residue from the oil will be

$$\frac{741,000}{100} \times \frac{1.95}{16} = 905.0\#$$

The actual deposit as determined by tests was

$$5779.7 \times .2295 = 1326\#$$

The excess, $421\#$, was left on brickwork or burned out during blast.

The amounts of initial volumes of air used on Tuesday and Saturday are in the ratio of $\frac{91400}{74650}$ (From Air Log data)

Assuming that for these preliminary blasts, which are for the purpose of bringing the machine up to heat from a cold state, that 30% air passes through without reacting on carbon, we have $(91400 - 74650) \cdot 30 = 5030$ feet of air.

This when burned, represents $\frac{5030}{84.7} \times 100 = 5940$ feet of gas. The heat stored in the coke bed by the burning of this amount of gas would be $\frac{5940 \times .0912 \times 1.98 \times 12}{16 \times 44} \times 14580 = 2,660,000 \text{ B.T.U.}$

Thus the net heat stored in the coke bed during blasting was $41,230,000 - 2,660,000 = 38,570,000$ BTU.

By the reduction of CO_2 to CO , the increase in volume will be $\frac{741,000}{100} \times 3.61 = 26750$ feet.

Volume of gases escaping from stack will thus be $741,000 + 26,750 = 767,750$ feet.

With a total steam consumption of 7496#, the volume of blue water gas made during the test was

$$\frac{7496 \times 100}{3.751} = 200,000 \text{ feet.}$$

By a set of computations similar to those used for the Saturday test we find the heat introduced into the generator distributed as follows:

Heat stored in fuel bed during blast	38,570,000 BTU
Heat entering with dry steam	8,450,000 "
Heat entering with dry air	2,970,000 "
Heat entering with steam moisture	21,600 "
Heat entering with air moisture	4,650 "
Total	50,016,250 "

This amount of heat introduced into the generator was absorbed or dissipated in the following manner:

Heat leaving as sensible heat in blast gases	17,950,000 BTU	
Heat required for the production of blue water gas	14,079,000	"
Heat leaving as sensible heat in blue water gas	6,190,000	"
Heat required to superheat dry steam	4,950,000	"
Heat required to vaporize and superheat coke moisture	1,560,000	"
Heat lost as radiation and convection	1,407,000	"
Heat required to superheat moisture in gas	1,140,000	"
Heat remaining in fuel bed	1,044,000	"
Heat remaining in brick lining	690,000	"
Heat required to vaporize and superheat blast moisture	363,000	"
Heat required to vaporize and superheat steam moisture	196,000	"
Heat unaccounted for	447,250	"
Total	50,016,250 BTU	

Generator Efficiency =

$$\frac{14,079,000 + 6,190,000}{50,016,250} = 41.5\%$$

CALCULATIONS FOR CARBURETTER AND SUPERHEATER

Test of Tuesday, February 16, 1909

7:30 A.M. to 6:00 P.M.

CALCULATIONS FOR CARBURETTER AND SUPERHEATER.

Test of Tuesday, February 16th, 1909

7:30 A.M. to 6:00 P.M.

The distribution of the various quantities of heat was as outlined for the Saturday Test, and the values of the various quantities are given below.

A correction was made, however, to the amount of heat liberated by the burning of CO to CO₂ in the carburetter, since reference to the Log Data of the air blast and the preliminary calculations shows that for the first two hours on Tuesday morning not enough secondary air was admitted to burn the gases completely. If sufficient secondary air had been admitted, however, the heat liberated would have been 30,800,000 BTU, the calculation being made as outlined before. For equal volumes of primary air used for approximately the first two hours on Saturday and Tuesday mornings, equal to 156,980 cubic feet, we find the volumes of secondary air to be 50,060 feet and 39,200 feet respectively. The heat liberated in the carburetter during this time (with sufficient secondary air for complete combustion) would be

$$\frac{156,980}{537,490} \times 30,800,000 = 8,990,000 \text{ BTU}$$

Since, however, there was a deficiency of

$50,060 - 39200 = 10,860$ feet of air, the amount of heat which must be deducted from 30,800,000 BTU is

$$\frac{10,860}{50,060} \times 30,800,000 = 1,950,000 \text{ BTU}$$

The corrected value of heat liberated by the burning of CO to CO_2 in the carburetter is now

$$30,800,000 - 1,950,000 = 28,850,000 \text{ BTU}$$

The heat introduced into the carburetter is distributed as follows:

Heat liberated by the burning of CO	28,850,000 BTU
Sensible heat in blast gases	17,950,000 "
Sensible heat in blue water gas	6,190,000 "
Sensible heat in the oil	324,500 "
Sensible heat in secondary air	14,580 "
Sensible heat in air moisture	<u>1,160 "</u>
Total	53,330,240 "

This amount of heat was dissipated as follows:

Heat left stored in brickwork	25,220,000 BTU
Sensible heat in carburetted gas	9,390,000 "
Sensible heat in blast gases	7,100,000 "
Heat necessary to "crack" oil	5,410,000 "
Heat absorbed by reduction of CO ₂	3,125,000 "
Heat lost by radiation and convection	2,640,000 "
Heat required to superheat air moisture	90,520 "
Heat unaccounted for	<u>354,720 "</u>
Total	53,330,240 "

Carburetter Efficiency =

$$\frac{9,390,000 + 5,410,000}{53,330,240} = 27.8\%$$

HEAT BALANCE

Distribution of Heat in Percentage of Input.

<u>Generator:</u>		
	<u>Test #1.</u>	<u>Test #2.</u>
Sensible heat leaving in blast gases	33.51	35.85
Heat required to produce blue water gas	28.01	28.10
Sensible heat leaving in blue water gas	12.28	12.38
Heat required to superheat dry steam	9.87	9.89
Heat required to vaporize and superheat coke moisture	6.21	3.12
Heat lost by radiation and convection	2.64	2.81
Heat required to superheat moisture in gas	2.43	2.28
Heat left in fuel bed	1.96	2.19
Heat left in brick lining	1.30	1.38
Heat required to vaporize and superheat blast moisture	0.81	0.73
Heat required to vaporize and superheat steam moisture	0.38	0.39
Heat unaccounted for	<u>0.60</u>	<u>0.88</u>
	100.00	100.00

<u>Carburetter and Superheater:</u>		
	<u>Test #1</u>	<u>Test #2</u>
Heat left in brickwork	45.50	47.40
Sensible heat leaving in carburetted gas	18.10	17.60
Sensible heat leaving in blast gases	13.20	13.30
Heat required to crack oil	10.88	10.10
Heat absorbed by reduction of CO ₂	6.83	5.85
Heat lost by radiation and convection	4.77	4.95
Heat required to superheat blast moisture	0.26	0.17
Heat unaccounted for	<u>0.46</u>	<u>0.63</u>
	100.00	100.00

SaturdayInput

Coke - -	10,406 x 12,983	=	135,800,000
Oil - -	885.03 x 142,100	=	126,000,000
Steam -	7808.3 x 1146	=	8,950,000
	123.9 x 180	=	<u>22,250</u>
			270,772,250 BTU
Ash recovered	986.9 x 4762	=	<u>- 4,705,000</u>
	Net		266,067,250 BTU

Output

Gas - - -	228,900 x 626	=	143,200,000 BTU
Tar - - -	16,266 x 670	=	<u>10,900,000</u>
	Total		154,100,000 BTU

Thermal Efficiency = 58.0%

The amount of tar recovered was but 570#. This was not the total amount actually removed from the gas, since it was impossible to obtain the whole amount from the tar extractor and condenser seal. By increasing the amount to 670#, this value was within 100% of the actual amount by the estimate of the Superintendent of the Gas Works. This error affects the efficiency above only slightly.

TuesdayInput

Coke - - -	11,102 x 12,815 =	142,800,000
Oil - - -	796.1 x 141,400 =	112,800,000
Steam - -	(7376 x 1146 =	8,450,000
	(120 x 180 =	<u>21,600</u>
		264,071,600 BTU
Ashes recovered	986.6 x 1842 =	<u>- 1,818,000</u>
	Net	262,253,600 BTU

Output

Gas - - -	215,800 x 623 =	134,200,000 BTU
Tar - - -	16,266 x 670 =	<u>10,900,000</u>
	Total	145,100,000 BTU

Thermal Efficiency = 55.4%

General Resultant Data

	<u>Test #1</u>	<u>Test #2</u>
Gallons of Oil per 1000 feet of purified gas	3.685	3.690
Pounds of steam per 1000 feet of blue water gas	37.50	37.45
Pounds of steam per 1000 feet of purified gas	34.60	34.80
Pounds of Dry Coke per 1000 feet of blue water gas	21.0	20.3
Total pounds of dry coke per 1000 feet of purified gas	45.5	51.5

Efficiencies

Generator	Carburetter & Superheater	Set
Test #1 40.3%	29.0%	58.0%
Test #2 40.5%	27.8%	55.4%

SUMMARY

SUMMARY.

It has been previously stated that the object of these tests was to determine a heat balance for the water gas set and to find the commercial efficiency of the machine. Such an analysis of heat distribution was made for the purpose of comparing the magnitudes of the various losses and showing to what extent some of them might be reduced for a more economical operation of the plant.

A comparison of the results of the two tests shows that a considerable amount of heat was required to vaporize and superheat the moisture in the form of ice and snow entering the generator with the coke. An inspection of the coke analyses shows the amounts of moisture in the coke to be very high, ranging from 14.82% for Test #1 to 7.46% for Test #2. The reason for such high percentages of moisture lies in the fact that all coke used during the tests was drawn from a pile which was not covered nor protected from the elements in any way. Were the coke to stand under cover, a saving of from 3% to 6% of the heat liberated might be effected -- the same amount of heat would be stored in the fuel bed for a shorter time of blasting. More efficient heating of the fuel bed would also take place with dry coke, for the frozen masses

of coke and ice which were introduced were too large to secure the best results.

An inspection of the Log Data and the Generator Calculations shows that insufficient secondary air was admitted for the complete combustion of blast gases in the carburetter during the first part of Test #2. With sufficient secondary blast, about 2,000,000 BTU or nearly 4% additional heat would have been liberated.

The total oil carbon deposited on the checker-work brick of the carburetter during Test #1 and Test #2 amounted to 1475# and 1326# respectively. With sufficient secondary blast to have completely burned out this carbon there would have been no reduction of CO_2 to CO and consequently a saving of about 8% of the heat input.

From the average of a large number of determinations of the quality of steam, taken both during the blast and during the run, it is seen that during the time of blasting, when the steam is standing in the pipe, the quality dropped only 0.60%. This small variation was due, no doubt, to the high temperature of the surrounding air and also to the fact that a number of auxiliary apparatus, such as steam pumps, were continuously drawing steam from the service main.

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LOG DATA

Temperatures in Machine.

Friday, February 12, 1909 - 7:25 P.M.

to

Saturday, February 13, 1909, -6:08 P.M.

<u>Time</u>	<u>Generator Couple #4 F^o</u>	<u>Carburetter Couple #6 F^o</u>	<u>Superheater Couple #5 F^o</u>	<u>Stack Couple #3 F^o</u>
7:25	770	1365	1260	
:39	972	1400	1292	
:40	1040	1400	1260	
:45	1100	1378	1260	
:54	1160	1365	1240	1080
:50	1470	1400	1240	
:51	1495	1400	1240	
:55	1415	1378	1240	
:56	1335	1370	1220	
8:01	1660	1415	1240	
:02	1620	1415	1240	
:04	1575	1395	1240	
:07	1550	1380	1225	
:11	1760	1445	1235	
:12	1695	1450	1255	
:15	1335	1405	1240	
:17	1230	1400	1240	
:20	1620	1415	1245	
:21	1615	1450	1280	

<u>Time</u>	<u>Generator Couple #4 F^o</u>	<u>Carburetter Couple #6 F^o</u>	<u>Superheater Couple #5 F^o</u>	<u>Stack Couple #3 F^o</u>
8:25	1530	1415	1245	
:30	1460	1395	1220	
Generator charged with coke				
8:36	900	1410	1225	1230
:37	990	1410	1225	
:40	1100	1380	1200	
:42	1120	1365	1200	
:45	1355	1405	1225	
:47	1420	1410	1225	
:50	1400	1380	1200	
:52	1420	1365	1190	1230
:55	1620	1410	1205	
:58	1620	1410	1205	
9:01	1575	1395	1200	
:03	1575	1390	1200	
:05	1740	1435	1225	
:07	1680	1420	1225	
:09	1620	1405	1210	
:11	1615	1394	1200	
:14	1765	1442	1235	
:17	1760	1478	1260	
:21	1290	1445	1270	
:23	1260	1433	1235	

<u>Time</u>	<u>Generator Couple #4 F°</u>	<u>Carburetter Couple #6 F°</u>	<u>Superheater Couple #5 F°</u>	<u>Stack Couple #3 F°</u>
9:25	1785	1481	1280	
:27	1710	1475	1280	
:30	1570	1451	1270	
Generator charged with coke				
9:44	1615	1448	1245	
:47	1080	1493	1290	
:49	1195	1493	1300	
:52	1140	1466	1280	
:56	1100	1472	1280	
:59	1395	1497	1300	
10:00	1385	1475	1280	
:01	1320	1460	1260	
:04	1405	1451	1270	
:07	1710	1490	1290	
:09	1790	1518	1340	
:14	1205	1460	1290	
:17	1205	1460	1280	1190
:20	1455	1478	1300	
:26	1495	1466	1300	
:28	1620	1478	1290	
:31	1570	1475	1290	
:34	1560	1436	1290	

Generator charged with coke

<u>Time</u>	<u>Generator Couple #4 F^o</u>	<u>Carburetter Couple #6 F^o</u>	<u>Superheater Couple #5 F</u>	<u>Stack Couple #3 F^o</u>
10:41	955	1430	1290	
:44	955	1448	1290	
:46	1140	1439	1290	
:49	1170	1394	1235	
:52	1355	1424	1260	
:54	1420	1415	1260	
:57	1410	1385	1235	
11:01	1550	1421	1260	1190
:04	1710	1460	1290	
:05	1640	1430	1280	
:08	1610	1418	1260	
:12	1685	1424	1270	
:15	1790	1469	1300	
:17	1775	1475	1310	
:19	1715	1469	1300	
:22	1765	1460	1290	
:25	1850	1504	1320	
:26	1715	1497	1310	
:29	1275	1466	1300	
:33	1495	1466	1320	
:36	1825	1507	1290	
:38	1775	1497	1290	

<u>Time</u>	<u>Generator Couple #4 F^o</u>	<u>Carburetter Couple #6 F^o</u>	<u>Superheater Couple #5 F^o</u>	<u>Stack Couple #3 F^o</u>
11:40	1660	1497	1280	
Generator charged with coke				
11:51	865	1475	1245	
:53	820	1475	1260	
:55	820	1475	1260	
:58	925	1445	1210	
12:00	910	1436	1210	
:03	1020	1445	1260	
:05	1100	1454	1235	
:08	1185	1424		
:10	1275	1415	1260	
:13	1620	1445	1280	
:14	1565	1445	1310	
:18	1460	1421	1300	
:21	1685	1445	1310	1190
:26	1935	1436	1360	
:27	1780	1504	1340	
:30	1275	1475	1320	
:34	1460	1475	1320	
:38	1770	1525	1360	
:40	1685	1497	1340	
:44	1580	1490	1320	

Shut down until 4:11 A.M.

<u>Time</u>	Start at 4:11 A.M.			
	<u>Generator Couple #4 F^o</u>	<u>Carburetter Couple #6 F^o</u>	<u>Superheater Couple #5 F^o</u>	<u>Stack Couple #3 F^o</u>
4:13	990	1355	1180	
:24	1425	1445	1235	
:29	1275	1394	1235	
:35	1760	1466	1270	
:39	1620	1436	1245	
:41	1540	1430	1235	
:45	1670	1454	1235	
:47	1915	1504	1290	
:50	1690	1478	1245	
:53	1610	1460	1270	
:56	1860	1504	1300	1190
:58	1980	1534	1340	
5:02	1335	1497	1320	
:04	1205	1487	1300	
:08	1420	1490	1320	1190
:10	1660	1531	1340	
:14	1585	1518	1340	
:16	1560	1497	1340	

Shut down until 7:47 A.M.

Start at 4:11 A.M.				
<u>Time</u>	<u>Generator Couple #4 F°</u>	<u>Carburetter Couple #6 F°</u>	<u>Superheater Couple #5 F°</u>	<u>Stack Couple #3 F°</u>
4:13	990	1355	1180	
:24	1425	1445	1235	
:29	1275	1394	1235	
:35	1760	1466	1270	
:39	1620	1436	1245	
:41	1540	1430	1235	
:45	1670	1454	1235	
:47	1915	1504	1290	
:50	1690	1478	1245	
:53	1610	1460	1270	
:56	1860	1504	1300	1190
:58	1980	1534	1340	
5:02	1335	1497	1320	
:04	1205	1487	1300	
:08	1420	1490	1320	1190
:10	1660	1531	1340	
:14	1585	1518	1340	
:16	1560	1497	1340	

Shut down until 7:47 A.M.

Start at 7:47 A.M.

<u>Time</u>	<u>Generator Couple #4 F^o</u>	<u>Carburetter Couple #6 F^o</u>	<u>Superheater Couple #3 F^o</u>
7:47	850	1610	
:54	2030	1570	
Generator charged with coke			
8:10	670	1525	
:21	955	1490	1420
:23	1005	1469	1410
:26	1120	1487	1400
:31	1470	1555	1448
:34	1430	1543	1440
:37	1420	1484	1430
:42	1645	1560	1448
:44	1710	1555	1448
:47	1620	1552	1440
:50	1590	1525	1430
:53	1700	1580	1460
:56	1820	1640	1500
9:00	1355	1585	1480
:02	1335	1565	1455
:06	1355	1540	1448
:08	1725	1610	1490
:09	1800	1625	1480
:11	1670	1590	1460

<u>Time</u>	<u>Generator Couple #4 F°</u>	<u>Carburettor Couple #6 F°</u>	<u>Superheater Couple #3 F°</u>
9:15	1585	1565	1455
:19	1485	1549	1440
Generator charged with coke			
9:22	1020	1575	1490
:26	830	1575	1490
:28	880	1531	1455
:31	910	1525	1448
:34	1040	1521	1460
:38	1510	1555	1455
:41	1425	1514	1448
:44	1410	1472	1430
:47	1735	1549	1448
:49	1810	1570	1470
:52	1665	1534	1440
:54	1585	1511	1430
10:00	1810	1570	1455
:02	1915	1585	1448
:05	1890	1555	1380
:08	1080	1531	1455
:11	1915	1600	1460
:13	1990	1620	1448
:15	1735	1585	1455
:19	1355	1507	1440

<u>Time</u>	<u>Generator Couple #4 F₀</u>	<u>Carburetter Couple #6 F₀</u>	<u>Superheater Couple #3 F₀</u>
Generator charged with coke			
10:23	1355	1565	1448
:26	1080	1570	1480
:34	1195	1511	1448
:36	1235	1475	1455
:38	1510	1549	1455
:40	1590	1565	1455
:43	1485	1481	1448
:45	1470	1469	1448
:47	1735	1552	1455
:50	1865	1590	1460
:52	1815	1585	1460
:56	1685	1552	1448
:59	1700	1590	1448
11:01	2005	1640	1470
:03	1735	1620	1470
:07	1355	1565	1455
:09	1880	1660	1520
:11	2200	1675	1525
:13	1850	1640	1480
:17	1590	1590	1470
Generator charged with coke			
11:20	1590	1580	1460

<u>Time</u>	<u>Generator Couple #4 F°</u>	<u>Carburetter Couple #6 F°</u>	<u>Superheater Couple #3 F°</u>
11:26	1020	1640	1510
:29	1120	1590	1510
:33	1140	1540	1480
:38	1460	1585	1490
:42	1445	1552	1480
:45	1455	1534	1470
:47	1665	1570	1480
:49	1685	1585	1490
:51	1620	1565	1490
:56	1640	1565	1455
:58	1805	1580	1460
:59	1790	1580	1470
12:02	1430	1565	1470
:06	1355	1534	1460
:08	1615	1560	1460
:09	1665	1570	1460
:12	1615	1540	1460
Generator charged with coke			
:22	880	1490	1430
:25	1040	1555	1440
:27	1195	1511	1430
:32	1205	1460	1430
:35	1310	1472	1430

<u>Time</u>	<u>Generator Couple #4 F^o</u>	<u>Carburetter Couple #6 F^o</u>	<u>Superheater Couple #3 F^o</u>
12:38	1530	1525	1430
:40	1530	1521	1440
:44	1510	1466	1430
:46	1565	1487	1430
:50	1725	1543	1440
:52	1685	1528	1430
:55	1655	1493	1420
:57	1660	1504	1430
1:00	1815	1560	1440
:02	1790	1555	1440
:05	1335	1521	1430
:09	1480	1525	1430
:11	1645	1560	1430
:15	1565	1514	1430
:18	1540	1490	1430
Generator charged with coke			
:21	1425	1490	1410
:22	1310	1490	1410
:25	1040	1497	1430
:26	1100	1521	1430
:28	1195	1500	1420
:31	1235	1457	1400
:34	1320	1466	1400

<u>Time</u>	<u>Generator Couple #4 F°</u>	<u>Carburetter Couple #6 F°</u>	<u>Superheater Couple #3 F°</u>
1:37	1510	1514	1420
:40	1505	1500	1420
:43	1505	1454	1380
:45	1585	1478	1410
:49	1785	1555	1430
:51	1715	1525	1430
:54	1670	1504	1420
:57	1780	1525	1430
:59	1820	1560	1430
2:01	1760	1565	1420
:05	1275	1497	1420
:07	1460	1525	1420
:10	1790	1590	1440
:12	1775	1555	1430
:14	1660	1525	1420
Generator charged with coke			
:18	1610	1500	1410
:21	1275	1514	1410
:23	990	1514	1410
:25	1020	1525	1410
:27	1100	1525	1410
:30	1205	1466	1410
:34	1220	1484	1490

<u>Time</u>	<u>Generator Couple #4 F_O</u>	<u>Carburetter Couple #6 F_O</u>	<u>Superheater Couple #5 F_O</u>
2:37	1535	1525	1420
:39	1530	1518	1420
:42	1445	1460	1400
:43	1460	1457	1390
	1455	1463	1400
:44	1535	1475	1400
	1600	1439	1400
:45	1665	1490	1400
	1715	1518	1400
:46	1740	1525	1400
	1785	1531	1400
:47	1790	1521	1400
	1780	1525	1400
:48	1725	1518	1400
	1685	1514	1390
:49	1660	1514	1400
	1645	1507	1400
:50	1630	1490	1400
	1610	1493	1400
:51	1610	1490	1400
	1590	1487	1390
:52	1585	1484	1400
	1585	1481	1400

<u>Time</u>	<u>Generator Couple #4 F^o</u>	<u>Carburetter Couple #6 F^o</u>	<u>Superheater Couple #3 F^o</u>
2:53	1580	1466	1400
	1570	1466	1390
:54	1610	1484	1380
	1680	1493	1315
:55	1725	1507	1390
	1790	1521	1390
:56	1805	1528	1400
	1810	1543	1410
:57	1830	1552	1410
	1810	1540	1410
:58	1775	1531	1410
	1640	1525	1400
:59	1565	1525	1400
	1505	1500	1400
3:00	1425	1511	1400
	1405	1500	1400
:01	1335	1487	1400
	1310	1490	1400
:02	1260	1481	1400
	1230	1475	1400
:03	1205	1466	1400
	1205	1466	1400

<u>Time</u>	<u>Generator Couple #4 F^o</u>	<u>Carburetter Couple #6 F^o</u>	<u>Superheater Couple #3 F^o</u>
3:04	1230	1478	1390
	1310	1487	1380
:05	1420	1500	1390
	1510	1514	1400
:06	1580	1525	1410
	1655	1534	1410
:07	1715	1549	1410
	1735	1555	1410
:08	1785	1568	1420
	1805	1572	1430
:09	1810	1580	1430
	1825	1578	1430
:10	1820	1572	1420
	1790	1565	1410
:11	1735	1555	1410
	1715	1552	1410
:12	1690	1549	1410
	1670	1534	1410
:13	1660	1531	1410
	1660	1528	1410
:14	1645	1525	1410
	1640	1525	1410

<u>Time</u>	<u>Generator Couple #4 F^o</u>	<u>Carburetter Couple #6 F^o</u>	<u>Superheater Couple #3 F^o</u>
3:15	1615	1521	1410
	1610	1518	1400
Generator charged with coke			
:16	1610	1514	1400
	1610	1507	1400
:17	1600	1497	1400
	1585	1493	1400
:18	1580	1497	1400
	1645	1511	1400
:19	1455	1514	1400
	1335	1521	1400
:20	1205	1525	1400
	1170	1525	1400
:21	1080	1525	1400
	1040	1528	1400
:22	1040	1531	1400
	1040	1537	1400
:23	1040	1546	1410
	1080	1549	1410
:24	1120	1528	1410
	1160	1525	1410
:25	1170	1525	1410
	1185	1525	1410

<u>Time</u>	<u>Generator Couple #4 F°</u>	<u>Carburetter Couple #6 F°</u>	<u>Superheater Couple #3 F°</u>
3:26	1185	1521	1410
	1195	1511	1410
:27	1195	1500	1410
	1205	1493	1400
:28	1205	1487	1400
	1205	1484	1400
:29	1205	1481	1400
	1205	1472	1400
:30	1220	1478	1400
	1230	1487	1390
:31	1250	1490	1390
	1275	1497	1390
:32	1310	1507	1400
	1355	1518	1400
:33	1425	1525	1400
	1505	1534	1410
:34	1540	1543	1410
	1585	1552	1410
:35	1610	1546	1410
	1580	1537	1410
:36	1560	1531	1410
	1530	1525	1410

<u>Time</u>	<u>Generator Couple #4 F^o</u>	<u>Carburetter Couple #6 F^o</u>	<u>Superheater Couple #3 F^o</u>
3:37	1510	1521	1400
	1505	1518	1410
:38	1495	1511	1410
	1485	1500	1410
:39	1485	1493	1410
	1485	1490	1400
:40	1480	1487	1400
	1480	1484	1400
:41	1485	1478	1400
	1505	1487	1400
:42	1560	1490	1400
	1640	1500	1400
:43	1680	1518	1400
	1730	1525	1410
:44	1785	1537	1410
	1830	1549	1420
:45	1815	1560	1420
	1825	1560	1420
:46	1815	1552	1420
	1780	1549	1410
:47	1730	1546	1410
	1710	1537	1410

<u>Time</u>	<u>Generator Couple #4 F^o</u>	<u>Carburetter Couple #6 F^o</u>	<u>Superheater Couple #3 F^o</u>
3:37	1510	1521	1400
	1505	1518	1410
:38	1495	1511	1410
	1485	1500	1410
:39	1485	1493	1410
	1485	1490	1400
:40	1480	1487	1400
	1480	1484	1400
:41	1485	1478	1400
	1505	1487	1400
:42	1560	1490	1400
	1640	1500	1400
:43	1680	1518	1400
	1730	1525	1410
:44	1785	1537	1410
	1830	1549	1420
:45	1815	1560	1420
	1825	1560	1420
:46	1815	1552	1420
	1780	1549	1410
:47	1730	1546	1410
	1710	1537	1410

<u>Time</u>	<u>Generator Couple #4 F^o</u>	<u>Carburetter Couple #6 F^o</u>	<u>Superheater Couple #3 F^o</u>
3:48	1685	1534	1410
	1670	1525	1410
:49	1660	1525	1410
	1655	1521	1410
:50	1645	1518	1410
	1630	1504	1410
:51	1630	1500	1410
	1620	1497	1410
:54	1610	1500	1410
:57	1965	1600	1455
:59	1830	1588	1455
4:03	1320	1543	1440
:06	1430	1552	1430
:10	1830	1630	1460
:12	1805	1605	1460
:15	1665	1575	1460
Generator charged with coke			
:18	1630	1560	1455
:21	1220	1572	1455
:24	1205	1595	1460
:26	1310	1583	1460
:30	1345	1528	1440
:32	1425	1534	1440

<u>Time</u>	<u>Generator Couple #4 F^o</u>	<u>Carburetter Couple #6 F^o</u>	<u>Superheater Couple #5 F^o</u>
4:35	1810	1583	1455
:37	1725	1580	1448
:40	1600	1565	1448
:43	1685	1555	1448
:46	1865	1586	1455
:48	1810	1580	1455
:52	1690	1555	1448
:54	1830	1575	1455
:56	1980	1620	1500
:58	1850	1610	1500
5:01	1405	1580	1500
:03	1530	1575	1490
:06	1805	1605	1500
:08	1735	1590	1490
:12	1660	1565	1490
:13	1645	1560	1490
Generator charged with coke			
:15	1600	1555	1470
:16	1425	1565	1480
:22	1580	1605	1490
:24	1565	1581	1490
:27	1510	1552	1480

<u>Time</u>	<u>Generator Couple #4 F^o</u>	<u>Carburetter Couple #6 F^o</u>	<u>Superheater Couple #3 F^o</u>
5:31	1715	1575	1480
:34	1865	1635	1480
:37	1735	1595	1490
:39	1710	1580	1490
:42	1865	1581	1480
:44	2030	1632	1490
:46	1680	1605	1480
:51	1345	1680	1490
:55	1510	1570	1460
:58	1740	1583	1480
6:01	1615	1565	1470
:04	1585	1570	1470
:08	1580	1546	1470

Temperatures in Machine

Tuesday, February 16, 1909

7:38 A.M. to 5:42 P.M.

<u>Time</u>	<u>Generator Couple #5 F^o</u>	<u>Carburetter Couple #6 F^o</u>	<u>Superheater Couple #3 F^o</u>	<u>Stack Couple #4 F^o</u>
7:38	1140	1540	1340	
:45	1020	1549	1400	
:52		1580	1444	
8:00	1854			
	1548			
:01	1456			
	1402			
:02	852			
	866			
:03	932	1555	1420	
	900			
:04	906			
	816			
:05	758			
	730			
:06	680	1549	1410	
	646			
:07	644			
	610			

<u>Time</u>	<u>Generator Couple #5 F^o</u>	<u>Carburetter Couple #6 F^o</u>	<u>Superheater Couple #3 F^o</u>	<u>Stack Couple #4 F^o</u>
8:08	586			
	586			
:09	546			
	546			
:10	530	1511	1400	
	540			
:11	546			
	546			
:12	546			
	492			
:13	586			
	550			
:14	486			
	512			
:15	678			
	658			
:16	812			
	816			
:17	820	1521	1410	
	860			
:18	866			
	890			

<u>Time</u>	<u>Generator Couple #5 F^o</u>	<u>Carburettor Couple #6 F^o</u>	<u>Superheater Couple #3 F^o</u>	<u>Stack Couple #4 F^o</u>
8:19	906			
	914			
:20	936	1552	1410	
	944			
:21	944			
	958			
:22	958	1497	1390	
	972			
:23	972			
	986			
:24	1002			
	980			
:25	986			
	1058			
:26	1092			
	1092			
:27	1046			
	1086			
:28	~~1132~~	1445	1350	
	1172			
:29	1202			
	1252			

<u>Time</u>	<u>Generator Couple #5 FO</u>	<u>Carburettor Couple #6 FO</u>	<u>Superheater Couple #3 FO</u>	<u>Stack Couple #4 FO</u>
8:30	1278			
	1298			
:31	1322			
	1368			
:32	1382			
	1416			
:33	1416	1484	1360	
	1412			
:34	1418			
	1416			
:35	1416	1484	1380	
	1402			
:36	1404			
	1406			
:37	1406			
	1402			
:38	1404			
	1406			
:39	1402	1493	1400	
	1382			
:40	1406			
	1430			

<u>Time</u>	<u>Generator Couple #5 Fo</u>	<u>Carburetter Couple #6 Fo</u>	<u>Superheater Couple #5 Fo</u>	<u>Stack Couple #4 Fo</u>
8:41	1452			
	1478			
:42	1512	1466	1380	
	1538			
:43	1562			
	1590			
:44	1588			
	1588			
:45	1586			
	1584			
:46	1562	1500	1380	
	1560			
:47	1558			
	1544			
:48	1540			
	1532			
:49	1522	1493	1410	
	1522			
:50	1512			
	1512			
:51	1542			
	1572			

<u>Time</u>	<u>Generator Couple #5 F^o</u>	<u>Carburetter Couple #6 F^o</u>	<u>Superheater Couple #3 F^o</u>	<u>Stack Couple #4 F^o</u>
8:52	1594			
	1630			
:53	1648	1466	1370	
	1662			
:54	1682			
	1700			
:55	1682			
	1632			
:56	1592	1525	1400	
	1412			
:57	894			
	946			
:58	916	1552	1410	
	844			
:59	866			
	806			
9:00	764			
:03		1490	1380	
:05		1484	1360	
:08		1531	1390	
:10		1555	1410	
Generator charged with coke				
:12		1546	1420	

<u>Time</u>	<u>Generator Couple #5 F^o</u>	<u>Carburetter Couple #6 F^o</u>	<u>Superheater Couple #3 F^o</u>	<u>Stack Couple #4 F^o</u>
9:16		1497	1370	
:21		1460	1325	
:25		1484	1340	
:27		1490	1350	
:29		1484	1350	
:33		1436	1325	
:37		1487	1340	1205
:39		1514	1350	
:42		1466	1325	
:45		1433	1320	
:48		1493	1325	
:51		1525	1340	
:56		1460	1320	
10:00		1525	1325	
:01		1555	1350	
:06		1490	1325	
:08		1463	1320	
:11		1521	1325	
Generator charged with coke				
:12		1534	1340	
:15		1507	1325	
:17		1484	1320	

<u>Time</u>	<u>Generator Couple #5 F^o</u>	<u>Carburettor Couple #6 F^o</u>	<u>Superheater Couple #3 F^o</u>	<u>Stack Couple #4 F^o</u>
9:16		1497	1370	
:21		1460	1325	
:25		1484	1340	
:27		1490	1350	
:29		1484	1350	
:33		1436	1325	
:37		1487	1340	1205
:39		1514	1350	
:42		1466	1325	
:45		1433	1320	
:48		1493	1325	
:51		1525	1340	
:56		1460	1320	
10:00		1525	1325	
:01		1555	1350	
:06		1490	1325	
:08		1463	1320	
:11		1521	1325	
Generator charged with coke				
:12		1534	1340	
:15		1507	1325	
:17		1484	1320	

<u>Time</u>	<u>Generator Couple #5 F^o</u>	<u>Carburetter Couple #6 F^o</u>	<u>Superheater Couple #3 F^o</u>	<u>Stack Couple #4 F^o</u>
10:20		1487	1315	
:25		1493	1325	1220
:28		1546	1340	
:33		1475	1325	
:36		1507	1325	
:37				
	1426			
:38	1388	1528	1340	
	1402			
:39	1412			
	1442			
:40	1492			
	1542			
:41	1592			
	1622			
:42	1662	1487	1325	
	1672			
:43	1660			
	1652			
:44	1632	1484	1325	
	1628			
:45	1622			
	1620			

<u>Time</u>	<u>Generator Couple #5 F^o</u>	<u>Carburetter Couple #6 F^o</u>	<u>Superheater Couple #3 F^o</u>	<u>Stack Couple #4 F^o</u>
10:46	1620	1528	1340	
	1618			
:47	1618	1549	1350	
	1616			
:48	1616			
	1636			
:49	1694			
	1728			
:50	1760			
	1792			
:51	1840			
	1836			
:52	1810	1484	1325	
	1786			
:53	1766			
	1752			
:54	1732			
	1724			
:55	1720			
	1714			
:56	1706	1555	1350	
	1706			

<u>Time</u>	<u>Generator Couple #5 Fo</u>	<u>Carburettor Couple #6 Fo</u>	<u>Superheater Couple #3 Fo</u>	<u>Stack Couple #4 Fo</u>
10:57	1706			
	1748			
:58	1794	1600	1400	
	1846			
:59	1876			
	1912			
11:00	1936			
	1967			
:01	1991	1578	1400	
	2005			
:02	2018			
	2005			
:03	2028			
	1939			
:04	1836	1518	1340	
	1746			
:05	1690			
	1650			
:06	1606			
	1566			
:07	1528			
	1472			

<u>Time</u>	<u>Generator Couple #5 F^o</u>	<u>Carburetter Couple #6 F^o</u>	<u>Superheater Couple #3 F^o</u>	<u>Stack Couple #4 F^o</u>
11:08	1438			
	1402			
:09	1394	1690	1480	1310
	1384			
:10	1366			
	1400			
:11	1460			
	1574			
:12	1726			
	1951			
:13	2035	1580	1430	
	2035			
:14	2035			
	1792			
:15	1610			
	1546			
:16	1508			
	1478			
:17	1466	1549	1400	
	1450			
	Coke started			
:18	1442			
	1428			

<u>Time</u>	<u>Generator Couple #5 F^o</u>	<u>Carburetter Couple #6 F^o</u>	<u>Superheater Couple #3 F^o</u>	<u>Stack Couple #4 F^o</u>
11:19	1424	1555	1400	
	1418			
:20	1408			
	1408			
:21	1482			
	1532			
:22	1574	1640	1430	
	Blast started			
:23	1146			
	830			
:24	830			
	654			
:25	726			
	796			
:26	842			
	894			
:27	940	1617	1430	
	990			
:28	1060			
	1128			
:29	1194			
	1260			
:30	1308	1645	1448	
	1364			

<u>Time</u>	<u>Generator Couple #5 Fo</u>	<u>Carburettor Couple #6 Fo</u>	<u>Superheater Couple #3 Fo</u>	<u>Stack Couple #4 Fo</u>
11:31	1408			
	1466			
:32	1524			
	1566			
:33	1600	1610	1448	
	1632			
:34	1574			
	1516			
:35	1514			
	1528			
:36	1532	1580	1430	
	1542			
:37	1546			
	1552			
:38	1550			
	1556			
:39	1566	1605	1440	
	1556			
:40	1556	1627	1440	
	1592			
:41	1714			
	1752			

<u>Time</u>	<u>Generator Couple #5 F^o</u>	<u>Carburetter Couple #6 F^o</u>	<u>Superheater Couple #3 F^o</u>	<u>Stack Couple #4 F^o</u>
11:42	1792			
	1822			
:43	1844			
	1874			
:44	1796			
	1700			
:45	1714	1571	1430	
	1720			
:46	1714			
	1712			
:47	1712			
	1710			
:48	1700			
	1694			
:49	1694			
	1694			
:50	1692	1525	1410	
	1692			
:51	1690			
	1690			
:52	1690			
	1686			

<u>Time</u>	<u>Generator Couple #5 F°</u>	<u>Carburetter Couple #6 F°</u>	<u>Superheater Couple #3 F°</u>	<u>Stack Couple #4 F°</u>
11:53	1686	1578	1430	
	1682			
:54	1682	1583	1430	
	1816			
:55	1880			
	1910			
:56	1930			
	1949			
:57	1969			
	1983			
:58	1995			
	1856			
:59	1800	1555	1430	
	1816			
12:00	1816			
	1812			
:01	1810			
	1798			
:02	1792			
	1788			
:03	1776			
	1772			

<u>Time</u>	<u>Generator Couple #5 Fo</u>	<u>Carburetter Couple #6 Fo</u>	<u>Superheater Couple #3 Fo</u>	<u>Stack Couple #4 Fo</u>
12:04	1712			
	1704			
:05	1704	1484	1380	
	1700			
:06	1696			
	1696			
:07	1690			
	1684			
:08	1684	1484	1380	
	1684			
:09	1995			
	1965			
:10	1987			
	1999			
:11	2023	1555	1390	
	2021			
:12	1997			
	1432			
:13	1434	1572	1390	
	1132			
:14	1072			
	1030			
:15	1008			
	992			

<u>Time</u>	<u>Generator Couple #5 F^o</u>	<u>Carburettor Couple #6 F^o</u>	<u>Superheater Couple #3 F^o</u>	<u>Stack Couple #4 F^o</u>
12:16	984	1534	1410	
	970			
:17	960			
	956			
:18	1196	1500	1390	
	1374			
:19	1580			
	1562			
:20	1716			
	1752			
:21	1802			
	1814			
:22	1842	1555	1410	1335
	1854			
:23	1638			
	1702			
:24	1710	1571	1410	
	1712			
:25	1710			
	1708			
:26	1706			
	1702			
:27	1700	1531	1410	
	1694			

<u>Time</u>	<u>Generator Couple #5 Po</u>	<u>Carburetter Couple #6 Po</u>	<u>Superheater Couple #3 Po</u>	<u>Stack Couple #4 Po</u>
12:28	1688			
	1688			
:29	1674			
	1674			
:30	1674			
	1672			
:31	1672			
	1672			
:32	1670	1484	1370	
	1670			
:33	1668			
	1668			
:34	1666			
	1666			
Blast started				
:35	1152	1460	1350	
	896			
:36	834			
	814			
:37	822			
	840			
:38	874			
	906			

<u>Time</u>	<u>Generator Couple #5 F^o</u>	<u>Carburetter Couple #6 F^o</u>	<u>Superheater Couple #3 F^o</u>	<u>Stack Couple #4 F^o</u>
12:39	946	1463	1325	
	984			
:40	1020			
	1070			
:41	1126			
	1166			
:42	1232	1463	1325	
	1282			
:43	1330			
	1368			
:44	1416			
	1464			
:45	1512	1490	1340	
	1552			
:46	1592			
	1526			
:47	1460			
	1450			
:48	1474	1525	1350	
	1488			
:49	1504			
	1510			

<u>Time</u>	<u>Generator Couple #5 F^o</u>	<u>Carburetter Couple #6 F^o</u>	<u>Superheater Couple #3 F^o</u>	<u>Stack Couple #4 F^o</u>
12:50	1514			
	1524			
:51	1524	1497	1360	
	1514			
:52	1520			
	1528			
:53	1532			
	1542			
:54	1542			
	1546			
:55	1552	1472	1350	
	1552			
:56	1554			
	1556			
:57	1556			
	1554			
:58	1554			
	1552			
:59	1550			
	1550			
1:00	1548	1439	1325	
	1694			

<u>Time</u>	<u>Generator Couple #5 F^o</u>	<u>Carburetter Couple #6 F^o</u>	<u>Superheater Couple #3 F^o</u>	<u>Stack Couple #4 F^o</u>
1:01	1732			
	1752			
:02	1776			
	1802			
:03	1816	1497	1350	
	1826			
:04	1848			
	1866			
:05	1880			
	1902			
:06	1914			
	1822			
:07	1728	1572	1410	
	1692			
:08	1728			
	1738			
:09	1738			
	1738			
:10	1736			
	1734			
:11	1732	1537	1390	
	1728			

<u>Time</u>	<u>Generator Couple #5 F^o</u>	<u>Carburetter Couple #6 F^o</u>	<u>Superheater Couple #3 F^o</u>	<u>Stack Couple #4 F^o</u>
1:12	1724			
	1718			
:13	1718			
	1718			
:14	1716			
	1712			
:15	1710			
	1708			
:16	1700			
	1698			
:17	1696			
	1672			
:18	1844	1475	1230	
	1844			
:19	1902			
	1924			
:20	1941			
	1961			
:21	1975	1490	1360	
	1995			
:22	2009			
	2021			

<u>Time</u>	<u>Generator Couple #5 F°</u>	<u>Carburetter Couple #6 F°</u>	<u>Superheater Couple #3 F°</u>	<u>Stack Couple #4 F°</u>
1:23	1936			
	1832			
:24	1796	1573	1400	
	1796			
:25	1828	1571	1400	
	1824			
:26	1820			
	1816			
:27	1808			
	1802			
:28	1800	1537	1390	
	1790			
:29	1780			
	1778			
:30	1774			
	1768			
:31	1764			
	1756			
:32	1752	1500	1390	
	1752			
:33	1744			
	1908			
:34	1959			
	1985			

<u>Time</u>	<u>Generator Couple #5 Fo</u>	<u>Carburetter Couple #6 Fo</u>	<u>Superheater Couple #3 Fo</u>	<u>Stack Couple #4 Fo</u>
1:35	2001	1500	1360	
	2017			
:36	2029			
	2009			
:37	2003			
	2010			
:38	2020			
	2035			
:39	2025			
	2021			
:40	1498	1623	1420	
	2010			
:41	1876			
	1498			
:42	1376	1610	1410	
	1304			
:43	1256			
	1212			
:44	1192			
	1170			
:45	1142	1583	1410	
	1128			
:46	1112			
	1102			

<u>Time</u>	<u>Generator Couple #5 F^o</u>	<u>Carburetter Couple #6 F^o</u>	<u>Superheater Couple #3 F^o</u>	<u>Stack Couple #4 F^o</u>
1:47	1226	1571	1410	
	1382			
:48	1452			
	1646			
:49	1716			
	1752			
:50	1790	1575	1400	
	1830			
:51	1854			
	1884			
:52	1906			
	1932			
:53	1941	1633	1400	
	1804			
:54	1758			
	1772			
:55	1776	1627	1420	
	1774			
:56	1772			
	1770			
:57	1764			
	1760			

<u>Time</u>	<u>Generator Couple #5 F°</u>	<u>Carburetter Couple #6 F°</u>	<u>Superheater Couple #3 F°</u>	<u>Stack Couple #4 F°</u>
1:58	1758	1583	1410	
	1754			
:59	1752			
	1750			
2:00	1746	Coke started 1568	1400	
	1746			
:01	1744			
	1740			
:02	1736			
	1736			
:03	1736			
	1736			
:04	1736	1534	1370	
	1728			
:05	1728			
:06		1521	1360	
:07	1983			
	1502			
:08	1652	1514	1360	
	1632			

<u>Time</u>	<u>Generator Couple #5 F°</u>	<u>Carburetter Couple #6 F°</u>	<u>Superheater Couple #3 F°</u>	<u>Stack Couple #4 F°</u>
2:09	1472			
	1022			
	Blast started			
:10	896			
	866			
:11	856	1518	1360	
	866	1531	1360	
:12	880	1537	1360	
	896	1537	1360	
:13	934	1534	1370	
	986	1534	1360	
:14	1024	1528	1370	
	1082	1525	1370	
:15	1112	1525	1370	
	1192	1525	1370	
:16	1212	1528	1370	
	1278	1531	1370	
:17	1322	1534	1370	
	1374	1537	1380	
:18	1402	1540	1380	
	1454	1546	1380	
:19	1484	1549	1390	
	1552	1549	1390	

<u>Time</u>	<u>Generator Couple #5 F^o</u>	<u>Carburetter Couple #6 F^o</u>	<u>Superheater Couple #3 F^o</u>	<u>Stack Couple #4 F^o</u>
2:20	1592	1555	1390	
	1622	1560	1400	
:21	1652	1568	1400	
	1686	1571	1400	
:22	1654	1575	1400	
	1592	1580	1400	
:23	1570	1581	1410	
	1544	1588	1410	
:24	1562	1588	1410	
	1572	1588	1410	
:25	1592	1584	1420	
	1598	1583	1420	
:26	1604	1580	1420	
	1652	1575	1410	
:27	1652	1573	1410	
	1656	1571	1410	
:28	1660	1568	1410	
	1666	1560	1410	
:29	1670	1555	1410	
	1674	1555	1410	
:30	1678	1552	1410	
	1676	1549	1410	

<u>Time</u>	<u>Generator Couple #5 F^o</u>	<u>Carburetter Couple #6 F^o</u>	<u>Superheater Couple #3 F^o</u>	<u>Stack Couple #4 F^o</u>
2:31	1686	1546	1410	
	1690	1543	1410	
:32	1690	1534	1410	
	1690	1531	1410	
:33	1690	1528	1410	
	1696	1525	1410	
:34	1696	1521	1400	
	1696	1518	1400	
:35	1696	1514	1400	
		1500	1400	
:36		1497	1390	
		1493	1390	
:37		1493	1390	
		1504	1390	
:38		1514	1390	
		1521	1390	
:39		1534	1400	
		1546	1400	
:40		1560	1410	
		1572	1410	
:41		1580	1430	
		1584	1430	

<u>Time</u>	<u>Generator Couple #5 F^o</u>	<u>Carburettor Couple #6 F^o</u>	<u>Superheater Couple #3 F^o</u>	<u>Stack Couple #4 F^o</u>
2:42		1595	1440	
		1610	1440	
:43		1630	1440	
		1640	1440	
:44		1646	1448	
		1640	1440	
:45		1632	1440	
		1617	1440	
:46		1610	1440	
		1605	1440	
:47		1515	1440	
		1590	1430	
:48		1584	1430	
		1581	1430	
:49		1580	1430	
		1580	1430	
:50		1578	1430	
		1573	1430	
:51		1575	1430	
		1580	1430	
:52		1580	1430	
		1580	1420	

<u>Time</u>	<u>Generator Couple #5 F^o</u>	<u>Carburettor Couple #6 F^o</u>	<u>Superheater Couple #3 F^o</u>	<u>Stack Couple #4 F^o</u>
2:42		1595	1440	
		1610	1440	
:43		1630	1440	
		1640	1440	
:44		1646	1448	
		1640	1440	
:45		1632	1440	
		1617	1440	
:46		1610	1440	
		1605	1440	
:47		1515	1440	
		1590	1430	
:48		1584	1430	
		1581	1430	
:49		1580	1430	
		1580	1430	
:50		1578	1430	
		1573	1430	
:51		1575	1430	
		1580	1430	
:52		1580	1430	
		1580	1420	

<u>Time</u>	<u>Generator Couple #5 F^o</u>	<u>Carburetter Couple #6 F^o</u>	<u>Superheater Couple #3 F^o</u>	<u>Stack Couple #4 F^o</u>
2:53		1580	1420	
		1581	1420	
:54		1584	1430	
		1590	1430	
:55		1595	1430	
		1590	1430	
:56		1586	1430	
		1583	1430	
:57		1581	1430	
		1580	1430	
:58		1580	1430	
		1575	1430	
:59		1575	1430	
		1573	1430	
3:00		1572	1430	
		1570	1430	
:01		1568	1430	
		1555	1430	
:02		1565	1430	
		1572	1430	
:03		1575	1430	
		1580	1430	

<u>Time</u>	<u>Generator Couple #5 F^o</u>	<u>Carburettor Couple #6 F^o</u>	<u>Superheater Couple #3 F^o</u>	<u>Stack Couple #4 F^o</u>
3:04		1584	1430	
		1595	1430	
:05		1610	1440	
		1620	1440	
:06		1617	1430	
		1610	1430	
:07		1610	1430	
		1605	1430	
:08		1595	1430	
		1538	1430	
:09		1583	1430	
		1580	1430	
:10		1578	1430	
		1573	1430	
:11		1572	1430	
		1570	1430	
:12		1565	1430	
		1571	1430	
:13		1573	1430	
		1580	1430	
:14		1584	1430	
		1595	1430	

<u>Time</u>	<u>Generator Couple #5 F°</u>	<u>Carburetter Couple #6 F°</u>	<u>Superheater Couple #3 F°</u>	<u>Stack Couple #4 F°</u>
3:15		1610	1430	
		1613	1440	
:16		1610	1440	
		1605	1440	
:17		1595	1430	
		1588	1430	
:18		1584	1430	
		1583	1430	
	Coke started			
:19		1581	1430	
		1580	1430	
:20		1578	1430	
		1573	1430	
	Blast started			
:21		1570	1430	
		1575	1430	
:22		1552	1430	
		1549	1430	
:23		1546	1430	
		1540	1420	
:24		1537	1420	
		1537	1420	

<u>Time</u>	<u>Generator Couple #5 F</u>	<u>Carburetter Couple #6 F^o</u>	<u>Superheater Couple #3 F^o</u>	<u>Stack Couple #4 F^o</u>
3:25		1534	1410	
		1537	1410	
:26		1549	1420	
		1552	1410	
:27		1546	1410	
		1540	1400	
:28		1534	1400	
		1531	1400	
:29		1528	1400	
		1531	1400	
:30		1534	1410	
		1540	1410	
:31		1546	1410	
		1549	1410	
:32		1552	1410	
		1555	1410	
:33		1555	1410	
		1560	1410	
:34		1555	1410	
		1555	1410	
:35		1552	1410	
		1546	1410	

<u>Time</u>	<u>Generator Couple #5 F^o</u>	<u>Carburetter Couple #6 F^o</u>	<u>Superheater Couple #3 F^o</u>	<u>Stack Couple #4 F^o</u>
3:36		1546	1420	
		1543	1420	
:37		1534	1420	
		1528	1420	
:38		1525	1420	
		1518	1410	
:39		1514	1410	
		1511	1410	
:40		1504	1410	
		1497	1400	
:41		1500	1400	
		1511	1400	
:42		1514	1400	
		1518	1400	
:43		1525	1400	
		1531	1400	
:44		1540	1400	
		1546	1410	
:45		1555	1410	
		1565	1410	
:46		1570	1410	
		1573	1420	

<u>Time</u>	<u>Generator Couple #5 F^o</u>	<u>Carburettor Couple #6 F^o</u>	<u>Superheater Couple #3 F^o</u>	<u>Stack Couple #4 F^o</u>
3:47		1573	1420	
		1571	1420	
:48		1568	1420	
		1555	1420	
:49		1555	1420	
		1549	1420	
:50		1546	1420	
		1534	1420	
:51		1528	1420	
		1525	1420	
:52		1521	1420	
		1514	1410	
:53		1507	1410	
		1504	1410	
:54		1504	1410	
		1514	1400	
:55		1518	1400	
		1525	1400	
:56		1534	1400	
		1546	1410	
:57		1555	1410	
		1565	1410	

<u>Time</u>	<u>Generator Couple #5 F°</u>	<u>Carburettor Couple #6 F°</u>	<u>Superheater Couple #3 F°</u>	<u>Stack Couple #4 F°</u>
3:58		1571	1410	
		1578	1410	
:59		1581	1410	
		1586	1420	
4:00		1584	1420	
		1581	1410	
:01		1580	1420	
		1575	1420	
:02		1572	1420	
		1570	1420	
:03		1565	1420	
		1555	1420	
:04		1552	1420	
		1546	1420	
:05		1540	1420	
		1534	1420	
:06		1528	1410	
		1525	1410	
:07		1525	1410	
		1531	1410	
:08		1531	1400	
		1534	1400	

<u>Time</u>	<u>Generator Couple #5 F^o</u>	<u>Carburettor Couple #6 F^o</u>	<u>Superheater Couple #3 F^o</u>	<u>Stack Couple #4 F^o</u>
4:09		1543	1400	
		1552	1400	
:10		1565	1400	
		1575	1400	
:11		1581	1400	
		1584	1410	
:12		1590	1420	
		1610	1420	
:13		1610	1420	
		1605	1430	
:14		1605	1430	
		1595	1430	
:15		1590	1430	
		1584	1430	
:16		1580	1430	
		1578	1430	
:17		1573	1430	
		1571	1420	
:18		1568	1420	
		1555	1420	
:19		1552	1420	
		1552	1420	

<u>Time</u>	<u>Generator Couple #5 F^o</u>	<u>Carburetter Couple #6 F^o</u>	<u>Superheater Couple #3 F^o</u>	<u>Stack Couple #4 F^o</u>
4:20		1555	1410	
		1565	1410	
:21		1573	1410	
		1578	1410	
:22		1581	1410	
		1588	1420	
:23		1595	1420	
		1610	1420	
:24		1617	1430	
		1627	1430	
:25		1632	1430	
		1632	1430	
:26		1620	1430	
		1610	1430	
:27		1605	1430	
		1595	1430	
:28		1590	1430	
		1588	1430	
:29		1584	1430	
		1581	1430	
	Coke started			
:30		1580	1430	
		1578	1430	

<u>Time</u>	<u>Generator Couple #5 F^o</u>	<u>Carburettor Couple #6 F^o</u>	<u>Superheater Couple #3 F^o</u>	<u>Stack Couple #4 F^o</u>
4:31		1575	1430	
		1573	1420	
:32		1572	1420	
		1570	1420	
:33		1568	1420	
		1560	1420	
:34		1555	1420	
		1555	1420	
:35		1552	1410	
		1552	1410	
Blast started				
:36		1549	1410	
		1546	1410	
:37		1543	1410	
:38				
:39				
:40		1531	1400	
		1543	1400	
:41		1546	1400	
		1546	1400	

<u>Time</u>	<u>Generator Couple #5 F^o</u>	<u>Carburettor Couple #6 F^o</u>	<u>Superheater Couple #3 F^o</u>	<u>Stack Couple #4 F^o</u>
4:42		1540	1400	
		1537	1400	
:43		1537	1400	
		1540	1400	
:44		1543	1400	
		1546	1400	
:45		1555	1400	
		1555	1400	
:46		1555	1400	
		1560	1400	
:47		1570	1410	
		1573	1410	
:48		1571	1410	
		1568	1410	
:49		1565	1410	
		1560	1410	
:50		1555	1410	
		1555	1410	
:51		1552	1410	
		1546	1410	
:52		1540	1410	
		1534	1400	

<u>Time</u>	<u>Generator Couple #5 F^o</u>	<u>Carburettor Couple #6 F^o</u>	<u>Superheater Couple #3 F^o</u>	<u>Stack Couple #4 F^o</u>
4:53		1528	1400	
		1521	1400	
:54		1518	1400	
		1514	1400	
:55		1511	1400	
		1514	1400	
:56		1521	1400	
		1525	1400	
:57		1531	1400	
		1537	1400	
:58		1546	1400	
		1555	1400	
:59		1565	1400	
		1570	1410	
5:00		1573	1410	
		1580	1410	
:01		1581	1410	
		1580	1410	
:02		1575	1410	
		1573	1410	
:03		1570	1410	
		1565	1410	

<u>Time</u>	<u>Generator Couple #5 F°</u>	<u>Carburettor Couple #6 F°</u>	<u>Superheater Couple #3 F°</u>	<u>Stack Couple #4 F°</u>
5:04		1555	1410	
		1552	1410	
:05		1549	1410	
		1546	1400	
:06		1540	1400	
		1534	1400	
:07		1531	1400	
		1525	1400	
:08		1528	1400	
		1534	1400	
:09		1543	1400	
		1549	1400	
:10		1560	1400	
		1570	1400	
:11		1575	1410	
		1581	1410	
:12		1588	1410	
		1600	1420	
:13		1613	1420	
		1623	1420	
:14		1627	1420	
		1620	1430	

<u>Time</u>	<u>Generator Couple #5 F^o</u>	<u>Carburetter Couple #6 F^o</u>	<u>Superheater Couple #3 F^o</u>	<u>Stack Couple #4 F^o</u>
5:15		1610	1430	
		1600	1430	
:16		1595	1430	
		1588	1430	
:17		1584	1430	
		1581	1430	
:18		1580	1430	
		1578	1430	
:19		1575	1420	
		1573	1420	
:20		1572	1420	
		1570	1420	
:21		1565	1420	
:22				
		1568	1420	
:23		1571	1420	
		1573	1420	
:24		1570	1420	
		1578	1420	
:25		1581	1410	
		1581	1410	

<u>Time</u>	<u>Generator Couple #5 F^o</u>	<u>Carburettor Couple #6 F^o</u>	<u>Superheater Couple #3 F^o</u>	<u>Stack Couple #4 F^o</u>
5:26		1583	1400	
		1583	1400	
:27		1584	1400	
		1584	1400	
:28		1586	1400	
		1588	1400	
:29		1583	1400	
		1580	1400	
:30		1575	1400	
		1572	1410	
:31		1568	1410	
		1565	1410	
:32		1560	1410	
		1552	1410	
:33		1549	1410	
		1546	1400	
:34		1546	1400	
		1546	1400	
:35		1546	1400	
		1543	1400	
:36		1537	1400	
		1531	1400	

<u>Time</u>	<u>Generator Couple #5 F</u>	<u>Carburettor Couple #6 F^o</u>	<u>Superheater Couple #3 F^o</u>	<u>Stack Couple #4 F^o</u>
5:37		1525	1400	
		1521	1400	
:38		1514	1400	
		1511	1400	
:39		1504	1400	
		1500	1400	
:40		1500	1400	
		1500	1400	
:41		1546	1400	
:44		1610	1420	
:45		1605	1420	
:49		1578	1410	
:53		1552	1410	

<u>Time</u>	<u>Generator Couple #5 F</u>	<u>Carburettor Couple #6 F</u>	<u>Superheater Couple #3 F</u>	<u>Stack Couple #4 F</u>
5:37		1525	1400	
		1521	1400	
:38		1514	1400	
		1511	1400	
:39		1504	1400	
		1500	1400	
:40		1500	1400	
		1500	1400	
:41		1546	1400	
:44		1610	1420	
:45		1605	1420	
:49		1578	1410	
:53		1552	1410	

Steam Consumption. February 13th, 1909.

<u>Time</u>	<u>Gage</u>	<u>Pounds per Minute</u>	<u>Duration in Minutes</u>	<u>Pounds of Steam</u>	
7:39	42.47	25.3	5.47	138.3	
:50	42.40	25.2	5.73	144.9	
8:01	40.90	25.0	5.93	148.2	
:11	43.89	25.5	4.72	120.4	Down run
:20	42.44	25.3	5.77	<u>145.9</u>	697.7 $\frac{7}{8}$
Generator charged with coke					
:36	41.76	25.2	5.58	140.8	
:46	41.33	25.1	5.50	138.1	
:56	41.68	25.1	6.33	159.0	
9:05	41.72	25.1	5.52	138.6	
:16	46.87	26.0	5.30	138.0	Down run
:26	41.59	25.1	6.28	<u>158.0</u>	872.5 $\frac{7}{8}$
Generator charged with coke					
:48	42.00	25.2	5.80	146.1	
:58	42.14	25.2	5.35	135.0	
10:07	46.40	25.9	6.00	155.4	
:18	42.18	25.2	5.83	147.0	Down run
:28	42.14	25.2	5.58	<u>140.9</u>	724.4 $\frac{7}{8}$
Generator charged with coke					
:44	41.86	25.2	5.85	147.3	
:53	41.64	25.2	6.12	154.1	
11:03	41.84	25.2	6.35	160.0	

<u>Time</u>	<u>Gage</u>	<u>Pounds per Minute</u>	<u>Duration in Minutes</u>	<u>Pounds of Steam</u>	
11:15	41.50	25.1	5.20	130.7	
:24	41.72	25.2	5.66	143.0	Down run
:36	42.28	25.3	6.72	<u>170.0</u>	905.1 ~~#~~

Generator charged with coke

:53	41.92	25.2	6.00	151.2	
12:03	42.34	25.3	5.35	135.1	
:12	42.15	25.2	6.52	154.2	
:25	42.70	25.3	6.65	168.1	Down run
:37	41.43	25.1	8.66	<u>217.5</u>	826.1 ~~#~~

Shut down until 4:00 o'clock

Large Holder Full

4:24	41.18	25.1	5.75	144.2	
:35	40.70	25.0	6.63	166.0	
:47	41.18	25.1	6.75	169.3	
:58	44.85	25.6	8.37	214.2	Down run
5:11	40.15	24.9	7.63	<u>182.1</u>	875.8 ~~#~~

Shut down for cleaning.

8:17	41.62	25.1	6.58	165.0	
:30	40.82	25.0	6.93	173.2	
:43	40.76	25.0	6.40	160.0	
:55	43.54	25.4	6.58	167.0	Down run
9:09	42.80	25.3	6.00	<u>151.8</u>	817.0 ~~#~~

Generator charged with coke

<u>Time</u>	<u>Gage</u>	<u>Pounds per Minute</u>	<u>Duration in Minutes</u>	<u>Pounds of Steam</u>	
9:26	41.38	25.1	6.08	152.8	
:38	41.12	25.1	6.35	159.5	
:49	39.33	24.8	5.75	142.2	
:59	41.62	25.1	6.03	151.5	Down run
10:11	45.00	25.7	5.80	<u>149.0</u>	755.0 ~~f~~

Generator charged with coke

:26	41.18	25.1	6.10	153.0	
:37	41.78	25.2	5.30	133.6	
:48	41.91	25.2	5.85	147.4	
:59	46.50	25.9	7.23	187.0	Down run
11:09	41.82	25.2	5.58	<u>140.8</u>	761.8 ~~f~~

Generator charged with coke

:25	41.24	25.1	6.55	164.3	
:36	41.14	25.1	6.28	157.8	
:46	41.45	25.1	6.08	152.8	
:57	40.86	25.0	6.10	152.5	Down run
12:07	41.81	25.1	6.75	<u>169.9</u>	797.3 ~~f~~

Generator charged with coke

:25	41.76	25.1	6.72	169.0	
:37	41.49	25.1	6.65	167.0	
:48	41.41	25.1	6.50	163.3	
:59	42.45	25.3	6.68	169.0	Down run
1:09	41.37	25.1	5.95	<u>149.5</u>	817.8 ~~f~~

<u>Time</u>	<u>Gage</u>	<u>Pounds per Minute</u>	<u>Duration in Minutes</u>	<u>Pounds of Steam</u>	
Generator charged with coke					
1:25	41.16	25.1	6.03	151.8	
:35	41.52	25.1	6.08	152.9	
:47	41.83	25.1	5.83	146.5	
:57	44.38	25.6	6.40	164.0	Down run
2:08	41.62	25.1	6.93	<u>174.1</u>	789.3 ~~#~~
Generator charged with coke					
2:24	41.66	25.1	6.55	164.6	
:35	41.10	25.1	6.75	169.8	
:46	41.28	25.1	6.43	161.6	
:56	42.00	25.2	6.83	172.1	Down run
3:08	41.22	25.1	6.77	<u>170.0</u>	838.1 ~~#~~
Generator charged with coke					
:23	41.12	25.1	6.58	165.3	
:34	41.34	25.1	6.48	162.5	
:44	41.26	25.1	6.83	171.8	
:56	43.34	25.4	6.32	160.6	Down run
4:08	41.32	25.1	6.52	<u>164.0</u>	824.2 ~~#~~
Generator charged with coke					
:22	41.93	25.2	6.90	174.0	
:35	41.37	25.1	6.97	175.1	
:45	41.36	25.1	6.40	161.0	
:55	38.13	24.6	5.93	143.3	Down run

<u>Time</u>	<u>Gage</u>	<u>Pounds per Minute</u>	<u>Duration in Minutes</u>	<u>Pounds of Steam</u>	
5:05	41.97	25.2	5.65	<u>142.5</u>	795.9 ~~f~~
Generator charged with coke					
:21	41.82	25.2	6.80	171.5	
:33	41.76	25.2	5.88	148.2	
:44	44.94	25.6	9.06	232.0	Down run
6:01	41.16	25.1	7.33	<u>184.1</u>	<u>735.8~~f~~</u>

Total Steam Consumption 12833.8~~f~~

Steam Consumption. February 16, 1909.

<u>Time</u>	<u>Gage</u>	<u>Pounds per Minute</u>	<u>Duration in Minutes</u>	<u>Pounds Steam</u>	
8:19	39.44	24.75	8.83	218.5	
:35	40.68	25.0	7.27	181.9	
:46	40.47	24.9	6.66	166.0	
:57	43.84	25.4	5.66	144.0	Down run
9:09	40.37	24.9	5.50	<u>137.0</u>	847.4 ~~7~~
Generator charged with coke					
9:25	40.29	24.9	7.05	175.3	
:38	40.64	25.0	6.83	171.0	
:49	40.23	24.9	6.22	155.0	
10:02	41.32	25.1	5.65	142.0	Down run
:12	41.39	25.1	4.88	<u>122.7</u>	766.0 ~~7~~
Generator charged with coke					
:28	40.65	25.0	5.55	139.0	
:37	40.65	25.0	5.48	137.2	
:46	40.87	25.0	5.50	137.6	
:58	42.47	25.3	6.57	166.1	Down run
11:09	40.73	25.0	7.00	<u>175.0</u>	754.9 ~~7~~
Generator charged with coke					
:29	40.35	24.9	6.52	162.3	
:40	40.41	24.9	10.33	257.0	
:54	40.57	25.0	12.95	324.0	

<u>Time</u>	<u>Gage</u>	<u>Pounds per Minute</u>	<u>Duration in Minutes</u>	<u>Pounds Steam</u>	
12:12	41.58	25.1	6.12	153.9	Down run
:23	40.15	24.9	10.92	<u>272.0</u>	1169.2 ~~f~~
Generator charged with coke					
:46	39.95	24.8	11.50	285.0	
1:06	40.80	25.0	10.66	266.3	
:22	40.97	25.0	9.92	248.0	
:39	38.63	24.6	5.50	135.4	Down run
:51	41.04	25.0	10.05	<u>258.0</u>	1192.7 ~~f~~
Generator charged with coke					
2:20	40.93	25.0	12.75	319.0	
:40	40.86	25.0	7.00	175.0	
:51	41.37	25.1	7.17	180.0	
3:03	44.25	25.6	5.77	148.0	Down run
:12	41.04	25.1	6.18	<u>155.2</u>	977.2 ~~f~~
Generator charged with coke					
:29	40.56	25.0	7.08	177.0	
:43	40.84	25.0	7.42	185.5	
:55	41.26	25.1	7.25	182.0	
4:09	43.45	25.5	6.08	155.2	Down run
:21	40.69	25.0	6.95	<u>173.9</u>	873.6 ~~f~~
Generator charged with coke					
:45	40.85	25.0	6.50	162.6	
:56	41.35	25.1	6.92	174.0	
5:10	40.80	25.0	7.83	195.8	

<u>Time</u>	<u>Gage</u>	<u>Pounds per Minute</u>	<u>Duration in Minutes</u>	<u>Pounds Steam</u>	
5:30	41.18	25.1	6.63	166.8	Down run
:42	41.26	25.1	8.58	215.8	915.0 ~~#~~
				<u>7496.0~~#~~</u>	Total Consumption

Oil Consumption

Friday, February 12, 1909 - 7:30 P.M.
to

Saturday, February 13, 1909 - 6:00 P.M.

Friday, February 12, 1909 - 7:30 P.M.

			Generator charged with coke		
<u>Time</u>	<u>Vol.in Gals.</u>	<u>Temp. C°</u>	<u>Time</u>	<u>Vol.in Gals.</u>	<u>Temp. C°</u>
7:44 P.M.	17.55	73.	9:48 P.M.	15.86	40.
:56	18.56	63.	10:03	18.90	51.
8:06	18.23	53.5	:13	17.56	48.
:16	17.90	47.	:23	17.90	48.
:26	<u>17.23</u>	<u>49.</u>	:33	<u>17.90</u>	<u>47.</u>
	89.47	57.1		88.12	46.8
Generator charged with coke			Generator charged with coke		
:36	18.23	42.	:49	19.59	42.
:46	18.90	52.	:57	17.90	50.
:56	19.25	48.	11:08	15.86	46.
9:05	16.54	44.	:19	17.56	47.
:16	19.25	45.	:30	17.90	49.
:25	<u>17.23</u>	<u>49.</u>	:40	<u>17.56</u>	<u>51.</u>
	109.40	46.6		106.37	47.5

Generator charged with coke

<u>Time</u>	<u>Vol. in Gals.</u>	<u>Temp. C°</u>
11:58 P.M.	17.56	44.
12:08 A.M.	16.21	45.
:17	17.56	52.
:24	18.56	46.
:43	<u>19.25</u>	<u>49.</u>
	89.14	47.2

Shut down until 4:00 A.M.

Generator charged with coke

4:24 A.M.	18.56	40.
:35	18.23	45.
:47	18.23	50.
:58	18.23	48.
5:11	<u>17.90</u>	<u>47.</u>
	91.15	46.0

Shut down to clean generator

Started at 7:40 A.M.

8:23 A.M.	18.23	48.
:30	18.23	53.
:44	18.23	54.
:56	16.89	52.
9:10	<u>19.25</u>	<u>53.</u>
	90.83	52.0

Generator charged with coke

<u>Time</u>	<u>Vol. in Gals.</u>	<u>Temp. C°</u>
9:26 A.M.	17.56	52.
:38	18.23	53.
:50	18.23	52.
10:00	17.90	50.
:11	<u>18.23</u>	<u>51.</u>
	90.15	51.6

Generator charged with coke

:32	18.23	44.
:42	17.90	52.
:53	17.90	42.
11:04	17.56	46.
:14	<u>17.56</u>	<u>48.</u>
	89.15	46.4

Generator charged with coke

:30	18.90	43.
:41	17.90	51.
:51	17.90	51.
12:02 P.M.	18.23	49.
:13	<u>17.90</u>	<u>48.</u>
	90.83	48.4

Generator charged with coke

<u>Time</u>	<u>Vol. in Gals.</u>	<u>Temp. C°</u>
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12:26 P.M.	19.59	45.
:37	17.90	55.
:48	17.56	51.
:59	18.56	51.
1:10	<u>17.90</u>	<u>50.</u>
	91.51	50.4

Generator charged with coke

<u>Time</u>	<u>Vol. in Gals.</u>	<u>Temp. C°</u>
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3:24 P.M.	17.23	56.
:34	19.59	55.
:45	17.23	50.
:57	17.56	52.
4:08	<u>18.23</u>	<u>49.</u>
	89.84	52.4

Generator charged with coke

1:25	18.90	46.
:35	18.56	53.
:47	17.56	49.
:58	18.90	54.
2:08	<u>18.23</u>	<u>46.</u>
	92.15	49.6

Generator charged with coke

4:22	17.56	48.
:35	18.23	56.
:46	18.23	53.
:56	17.90	51.
5:06	<u>16.21</u>	<u>50.</u>
	88.13	51.6

Generator charged with coke

2:25	16.89	53.
:36	20.60	54.
:47	19.25	48.
:57	16.89	49.
3:09	<u>17.23</u>	<u>45.</u>
	90.86	49.8

Generator charged with coke

5:21	19.25	55.
:33	16.54	52.
:44	18.23	55.
6:01	<u>17.56</u>	<u>58.</u>
	71.58	55.0

Total Oil Consumption 1458.68 Gal.

Average temperature of Oil 49.8°C or 121.6°F

Oil Consumption

Tuesday, February 16, 1909

7:37 A.M. to 5:42 P.M.

			Generator charged with coke		
<u>Time</u>	<u>Gals.Oil</u>	<u>Temp. C°</u>	<u>Time</u>	<u>Gals.Oil</u>	<u>Temp.C°</u>
8:28 A.M.	18.90	51.	11.27 A.M.	17.90	40.
:42	18.56	49.	:39	25.78	52.
:51	18.23	51.	12:03 P.M.	33.75	37.
9:02	18.90	53.	:12	16.54	51.
:14	<u>19.59</u>	<u>54.</u>	:22	<u>30.80</u>	<u>41.</u>
	94.18.	51.6		124.77	44.2

Generator charged with coke			Generator charged with coke		
9:26	17.56	59.	12:52	21.30	45.
:37	18.23	54.	1:07	26.05	39.
:49	17.90	48.	:24	28.10	39.
10:00	20.94	52.	:40	17.56	49.
:11	<u>15.86</u>	<u>51.</u>	:53	<u>29.75</u>	<u>56.</u>
	90.49	52.8		122.76	45.6

Generator charged with coke			Generator charged with coke		
:27	17.23	59.	2:22	23.68	63.
:36	17.56	57.	:42	19.59	45.
:45	14.85	52.	:53	18.23	48.
11:09	<u>19.25</u>	<u>47.</u>	3:03	18.56	46.
	68.89	53.0	:13	<u>18.56</u>	<u>48.</u>
				98.62	50.0

Generator charged with coke

<u>Time</u>	<u>Gals.Oil</u>	<u>Temp. C°</u>
3:31 P.M.	21.60	40.
:44	23.10	50.
:58	24.00	44.
4:10	17.23	42.
:23	<u>17.23</u>	<u>46.</u>
	103.16	44.4

Generator charged with coke

4:45	16.21	42.
:54	18.90	53.
5:11	23.68	46.
:25	16.21	41.
:44	<u>18.23</u>	<u>48.</u>
	93.23	46.0

Total Oil Consumption	796.1 Gals.
Average Temperature	48.4° C
or	119.1° F

AIR CONSUMPTION

February 12, 1909 to February 13, 1909
7.30 P.M. to 6.00 P. M.

<u>Primary</u>				<u>Secondary</u>		
<u>Time</u>	<u>Duration</u>	<u>Head in mm. Oil</u>	<u>Volume</u>	<u>Duration</u>	<u>Head in mm. Oil</u>	<u>Volume</u>
7:38	10.83	10.0	17800	7.80	6.0	4490
:50	5.96	12.2	11400	5.27	7.0	3430
8:00	4.00	12.3	7700	3.47	7.5	2400
:11	4.43	12.0	8400	4.05	7.5	2800
:20	3.10	12.3	5970	2.63	7.6	1840
Generator charged with coke						
:36	5.90	12.2	11300	3.62	6.0	2080
:46	3.93	13.2	7960	3.73	8.2	2760
:55	3.45	13.6	7130	4.03	8.0	2920
9:05	2.75	13.6	5650	2.50	8.5	1900
:16	5.33	13.2	10800	3.66	10.0	3130
:25	2.63	14.7	5700	2.17	9.0	1715
Generator charged with coke						
:48	5.45	13.3	11100	2.88	8.0	2090
:58	3.60	14.0	7590	2.98	8.0	2160
10:08	4.43	13.5	9120	4.05	8.5	3080
:18	2.08	13.5	4270	1.93	8.5	1460
:27	3.30	15.3	7400	2.90	8.8	2250

Generator charged with coke

<u>Primary</u>				<u>Secondary</u>		
<u>Time</u>	<u>Duration</u>	<u>Head in mm. Oil</u>	<u>Volume</u>	<u>Duration</u>	<u>Head in mm. Oil</u>	<u>Volume</u>
10:44	6.02	14.1	12700	3.10	9.0	2450
:53	3.03	14.4	6520	2.12	7.8	1520
11:04	4.28	14.5	9240	4.37	9.5	3620
:15	5.07	13.7	10560	4.37	14.2	4850
:25	4.05	12.9	8090	3.62	8.1	2640
:36	4.03	14.1	8540	3.72	8.7	2860
Generator charged with coke						
:53	3.83	13.8	8000	2.70	4.3	1080
12:03	3.53	14.0	7450	3.28	7.8	2330
:12	3.45	14.1	7300	2.83	7.2	1880
:25	6.53	13.5	13420	5.83	8.5	4420
:37	4.33	13.0	8670	3.93	8.4	2940
Shut down until 4 A.M.						
4:24	11.68	12.4	22600	6.87	8.1	5010
:35	5.58	12.4	10820	5.02	8.0	3640
:46	4.03	12.4	7820	3.75	8.1	2740
:58	3.96	12.3	7630	3.63	8.0	2630
5:10	4.92	12.3	<u>9500</u>	4.40	8.0	<u>3190</u>
Totals			298150	88305		

Shut down for cleaning

<u>Primary</u>				<u>Secondary</u>		
<u>Time</u>	<u>Duration</u>	<u>Head in mm. Oil</u>	<u>Volume</u>	<u>Duration</u>	<u>Head in mm. Oil</u>	<u>Volume</u>
Started at 7:40 A.M.						
7:40	16.73	11.4	30450	16.30	7.3	11000
8:04	17.16	11.4	31200	16.17	7.3	10920
:25	6.50	13.0	13000	5.75	8.4	4310
:39	5.63	13.3	11490	5.47	8.3	4070
:51	5.57	13.3	11300	5.38	8.3	4010
9:07	3.40	13.3	6800	3.25	8.3	2420
Generator charged with coke						
:21	5.73	14.5	12390	3.70	8.0	2680
:34	5.82	15.0	12880	4.12	8.0	2990
:46	4.27	15.2	9510	4.05	8.0	2940
:56	4.03	15.4	9080	3.87	8.0	2810
10:06	3.96	15.3	8860	3.87	8.0	2810
Generator charged with coke						
:21	6.52	16.0	15000	3.91	8.0	2840
:34	3.66	16.4	8560	3.02	8.0	2190
:43	5.07	15.4	11420	4.88	8.0	3540
:55	4.42	15.0	9780	4.25	8.0	3080
11:06	3.85	16.6	9110	3.72	8.0	2700
Generator charged with coke						

<u>Primary</u>				<u>Secondary</u>		
<u>Time</u>	<u>Duration</u>	<u>Head in mm. Oil</u>	<u>Volume</u>	<u>Duration</u>	<u>Head in mm. Oil</u>	<u>Volume</u>
11:21	4.48	15.7	10160	3.30	7.3	2230
:32	4.45	14.9	9780	3.72	8.0	2700
:43	4.02	13.4	8220	3.83	8.0	2780
:54	3.75	14.0	7900	3.30	7.3	2230
12:04	3.43	14.0	7220	3.17	7.0	2060
Generator charged with coke						
:18	7.93	12.0	15000	5.05	10.0	4320
:34	4.43	13.0	8860	4.02	8.0	2920
:45	4.45	13.7	9260	4.20	7.7	2960
:56	3.98	13.0	7960	3.80	8.0	2760
1:07	3.25	14.0	6850	3.08	8.0	2780
Generator charged with coke						
1:20	5.38	13.7	11200	3.55	8.0	2570
:32	3.98	13.7	8270	3.58	8.0	2600
:42	5.66	13.5	11640	5.48	8.0	3970
:54	3.43	13.5	7050	3.25	8.0	2360
2:04	4.08	14.0	8600	3.87	8.0	2810
Generator charged with coke						
:18	6.38	14.9	14030	3.55	8.8	2750
:31	4.25	15.0	9350	3.77	8.5	2860
:43	3.75	15.2	8350	3.60	9.2	2900

<u>Primary</u>				<u>Secondary</u>		
<u>Time</u>	<u>Duration</u>	<u>Head in mm. Oil</u>	<u>Volume</u>	<u>Duration</u>	<u>Head in mm. Oil</u>	<u>Volume</u>
2:53	3.32	14.8	7260	2.98	8.8	2310
3:04	5.13	14.7	11160	4.92	9.3	3990
Generator charged with coke						
:18	4.96	14.5	10720	2.95	8.0	2140
:30	4.20	15.1	9300	3.77	9.0	2980
:41	3.98	14.8	8720	3.53	9.2	2840
:52	4.60	14.3	9830	4.45	9.0	3520
4:04	4.60	14.9	10120	4.47	9.1	3550
Generator charged with coke						
:17	5.58	15.3	12500	3.80	8.3	2840
:29	5.10	14.4	10980	4.63	8.8	3590
:45	3.05	13.8	6380	2.97	9.2	2390
:57	3.42	15.3	7700	3.37	10.0	2880
5:02	2.87	14.8	6280	2.83	9.3	2300
Generator charged with coke						
:14	6.57	15.3	14700	4.02	9.7	3380
:28	4.83	15.3	10830	4.60	9.9	3910
:39	4.80	14.0	10120	3.17	8.3	2360
:59	3.48	13.1	<u>7000</u>	3.05	8.8	<u>2360</u>
Total for day run			534130 cu.ft.	163210 cu.ft.		

AIR CONSUMPTION

Tuesday, February 16th, 1909, 7:30 A.M.

<u>Time</u>	<u>Duration</u>	<u>Primary</u>	<u>Volume</u>	<u>Secondary</u>	<u>Volume</u>
		Head in mm. Oil		Head in mm. Oil	
7:37	16.77	13.0	33500	11.00	5820
8:02	15.87	13.2	32100	10.35	4920
:28	12.35	13.8	25800	11.42	6560
:42	4.85	12.7	9510	2.17	1150
:53	4.33	11.7	8050	4.03	2540
9:07	5.18	12.6	10170	3.08	2000

Generator charged with coke

:17	8.20	14.8	17960	6.88	3960
:33	4.88	16.0	11240	4.70	3060
:45	4.33	14.5	9360	4.13	2790
:56	4.27	14.0	9000	4.08	2760
10:08	3.05	15.0	6700	4.10	2830

Generator charged with coke

:19	8.78	14.1	18550	5.77	3240
:34	3.12	13.7	6490	2.90	1880
:43	3.15	14.3	6740	2.88	1870
:52	5.98	14.5	12920	5.00	3520
11:06	3.88	17.0	9210	3.68	2390

Generator charged with coke

:19	11.00	15.0	24300	9.37	5860
:36	3.47	12.0	2560	3.35	1930

<u>Time</u>	<u>Duration</u>	<u>Primary</u>		<u>Secondary</u>		
		<u>Head in</u> <u>mm. Oil</u>	<u>Volume</u>	<u>Duration</u>	<u>Head in</u> <u>mm. Oil</u>	<u>Volume</u>
11:50	4.05	14.0	8540	3.80	6.7	2400
12:06	4.73	13.0	9460	4.22	6.5	2570
:18	3.92	13.3	7970	3.77	7.0	2450
Generator charged with coke						
:37	11.58	12.8	22950	8.50	6.0	4890
1:00	5.75	14.0	12110	5.50	12.7	4610
:16	5.08	14.0	10700	5.12	8.5	3890
:32	6.22	14.0	13100	6.50	7.8	4620
:46	4.83	14.0	10200	5.02	7.0	3260
Generator charged with coke						
2:10	12.92	14.3	26850	10.50	7.2	6980
:33	6.57	14.0	13830	6.42	11.7	6160
:47	3.83	14.5	8270	1.68	6.5	1020
:58	3.50	14.0	7360	3.28	6.0	1880
3:08	3.18	14.0	6700	3.12	6.7	1970
Generator charged with coke						
:21	8.10	13.0	16200	5.30	6.0	3050
:37	5.42	13.0	10840	5.13	6.0	2950
:51	5.28	13.0	10560	5.10	6.0	2930
4:03	5.55	12.8	11020	5.10	6.0	2930
:15	5.55	12.8	11020	4.12	6.3	2470

Generator charged with coke

<u>Primary</u>				<u>Secondary</u>		
<u>Time</u>	<u>Duration</u>	<u>Head in mm. Oil</u>	<u>Volume</u>	<u>Duration</u>	<u>Head in mm. Oil</u>	<u>Volume</u>
4:36	7.38	14.2	15700	5.25	6.0	3020
:51	5.58	14.0	11760	5.17	6.8	3320
5:04	5.66	13.4	11600	5.53	7.4	3790
:17	4.50	14.3	9620	Not open		
:36	6.35	13.3	<u>12920</u>	5.60	7.0	<u>3640</u>
Total for day run			537,440 cu.ft.	133,880 cu.ft.		

Gas Moisture Determination

<u>Gas in cu.ft.</u>	<u>Condensation</u>		<u># per 100 cu. ft. of gas</u>
	<u>Cu.cm.</u>	<u>#</u>	
0.98	3.0	.0066	0.675
1.39	4.0	.0088	0.632
1.61	8.0	.0177	1.100
0.88	5.0	.0110	<u>1.250</u>
Average			0.914

Average Quality of Steam

		<u>Blast</u>	<u>Run</u>
Superheat Temperature		250.5	251.6
Manometer			
Mercury	Right	1.155	1.20
	Left	0.60	0.55
Water	Right	0.20	0.20
	Left	0.55	0.55
Quality - % Dry		97.8	98.4

Radiation and Convection Determination Data.

Radiation Loss.

	<u>Generator</u>	<u>Carburettor</u>	<u>Superheater</u>
Excess Temperature F°	219	169	161
Surface area in sq.ft.	332	404	518
K	3.30	3.30	3.30
BTU per sq.ft. per hr.	258	180	169
BTU loss per hr.	85,600	72,800	87,500
Duration in hours	10	10	10
Total Radiation loss in BTU	856,000	728,000	875,000

Convection Loss

K'	2.16	2.12	2.08
BTU per sq.ft. per hr.	166	118	108
BTU loss per hr.	55,100	47,700	56,000
Total Convection loss in BTU	551,000	477,000	560,000

Relative Amounts of Heat Necessary
to Vaporize Equal Volumes of
Water and Oil.
Temperatures in °F.

<u>Water</u>		<u>Oil</u>	
<u>Temperature</u>	<u>Drop in Temp.</u>	<u>Temperature</u>	<u>Drop in Temp.</u>
954	194	1647	93.4
963	194	1640	93.6
1310	182	1454	79.2
1254	185	1461	72.0
1492	187	1722	112.0
1512	187	1732	119.0
1672	196		
1682	186		
1692	178		

Specific Gravity of oil 0.87

ANALYSES

GAS ANALYSES. Test of Feb. 16, 1909Generator Blast

CO ₂	Hyd	C ₂	CO	CH ₄	H ₂	N ₂	Total
10.0		1.1	14.1			74.8	
9.4		1.0	14.4			75.2	
9.4		1.7	13.4			75.5	
8.8		1.8	13.4			76.0	
9.0		1.9	13.9			75.2	
9.0		1.8	13.0			76.2	
8.5		1.8	13.7			76.0	
<u>8.9</u>		<u>1.9</u>	<u>12.9</u>			<u>76.3</u>	
9.12		1.62	13.60			75.66	100.00

Superheater Blast

15.0	0.7	6.5		77.8	
13.9	0.4	7.5		78.2	
14.3	0.4	7.5		77.8	
14.9	0.6	7.2		77.3	
14.6	0.5	7.4		77.5	
<u>15.0</u>	<u>0.6</u>	<u>7.2</u>		<u>77.2</u>	
14.61	0.53	7.22		77.64	100.00

<u>Generator Run</u>							Total
CO ₂	Hyd	O ₂	CO	CH ₄	H ₂	N ₂	
3.9		1.2	43.3		37.3	14.3	
4.0		2.5	41.3				
					37.9	14.3	
3.1		1.5	44.0		40.6	10.8	
					38.7	12.7	
2.8		1.3	43.9		42.4	9.6	
3.1		0.9	43.6		40.0	12.4	
1.5		1.6	44.3		42.5	10.1	
					36.4	16.2	
<u>2.3</u>		<u>1.7</u>	<u>43.7</u>		<u>38.0</u>	<u>14.3</u>	
2.96		1.53	43.44		39.31	12.76	100.000

<u>Carburetter Run</u>							Total
2.2	11.6		33.6	17.2	31.1	4.3	
2.6	11.4		33.8	15.9	30.2	6.1	
3.0	11.8		33.5	16.4	29.9	5.4	
<u>3.4</u>	<u>11.7</u>		<u>33.5</u>	<u>14.5</u>	<u>33.0</u>	<u>3.9</u>	
2.80	11.63		33.60	16.00	31.05	4.92	100.00

Superheater Run

CO ₂	Hyd	O ₂	CO	CH ₄	H ₂	N ₂	Total
2.5	13.3	0.2	32.6	18.4	27.9	5.1	
				17.5	28.1	5.8	
2.4	12.8	0.4	32.6	19.9	24.1	7.8	
				17.4	27.6	6.8	
2.0	13.0	0.1	32.7	20.8	26.3	5.1	
<u>2.8</u>	<u>13.2</u>	<u>0.0</u>	<u>32.8</u>	<u>20.6</u>	<u>24.6</u>	<u>6.0</u>	
2.43	13.07	0.17	32.67	19.10	26.43	6.13	100.00

Purified Gas

3.3	12.2	0.5	30.0	20.1	29.1	4.8	
4.0	11.8	0.2	30.4	20.4	26.9	6.3	
3.0	12.2	0.3	30.7	18.7	28.2	6.9	
3.4	12.2	0.5	30.3	18.9	30.7	4.0	
<u>3.4</u>	<u>12.2</u>	<u>0.5</u>	<u>30.7</u>	<u>17.8</u>	<u>29.6</u>	<u>5.8</u>	
3.42	12.12	0.40	30.42	19.19	28.90	5.55	100.00

PROXIMATE ANALYSES

Feb. 13, 1909

Feb. 16, 1909

	<u>Coke</u>		<u>Ashes</u>		<u>Coke</u>		<u>Ashes</u>	
	1	2	1	2	1	2	1	2
Moisture	14.82	14.82	14.82	6.90	6.90	6.90	7.46	7.46
Volatile Matter	4.23	4.38	4.31	0	0	0	3.84	3.61
Fixed C	73.0	73.5	73.18	31.1	31.1	31.1	80.2	80.4
Ash	7.95	7.30	7.69	62.0	62.0	62.0	8.50	8.53
							8.52	76.90
							76.67	76.79

On Basis of Dry Coke

Moisture	0	0	0	0	0	0	0	0	0
Volatile Matter	4.97	5.14	5.06	0	0	0	4.15	3.90	4.02
Fixed C	85.70	86.29	85.91	33.4	33.4	33.4	86.65	86.89	86.77
Ash	9.33	8.57	9.03	66.6	66.6	66.6	9.20	9.21	9.21
							79.5	79.2	79.4

FRACTIONAL DISTILLATION
OF OIL

Original Volume 75 cc.

<u>Temp. F°</u>	<u>Volume</u>	<u>%</u>	<u>Color</u>
221	0.5	0.6	Light
292	1.1	1.5	Light
460	12.5	16.6	Light green tinge
590	51.0	68.1	Green tinge
637	6.0	8.0	Amber (heavy)
---	<u>3.9</u>	<u>5.2</u>	Black Residue
	75.0	100.0	

CALIBRATION DATA

Calibration Data for Steam Orifice.

Discharge Throttled.

<u>Corrected Dif- ferential in Inches of Mer- cury</u>	<u>Discharge in pounds of steam per minute</u>	<u>Corrected Dif- ferential in Inches of Mer- cury</u>	<u>Discharge in pounds of steam per minute</u>
67.20	29.4	32.81	23.0
62.50	27.9	31.29	22.9
61.98	28.5	27.23	21.8
60.90	27.8	27.14	21.6
60.18	27.2	26.50	21.8
57.76	26.4	24.60	21.6
55.70	25.8	23.15	21.6
53.59	27.4	20.43	20.1
52.09	26.3	19.24	19.4
50.72	25.9	18.25	19.0
47.65	26.0	15.71	18.0
46.69	25.6	14.95	17.7
45.07	25.0	14.86	18.1
41.04	25.8	11.90	16.1
40.96	25.4	10.21	14.8
39.50	24.4	8.48	13.0
35.14	23.9	6.32	11.9
34.49	24.1	3.15	7.8

Calibration Data for Steam Orifice.

Discharge Throttled.

<u>Corrected Dif- ferential in Inches of Mer- cury</u>	<u>Discharge in pounds of steam per minute</u>	<u>Corrected Dif- ferential in Inches of Mer- cury</u>	<u>Discharge in pounds of steam per minute</u>
67.20	29.4	32.81	23.0
62.50	27.9	31.29	22.9
61.98	28.5	27.23	21.8
60.90	27.8	27.14	21.6
60.18	27.2	26.50	21.8
57.76	26.4	24.60	21.6
55.70	25.8	23.15	21.6
53.59	27.4	20.43	20.1
52.09	26.3	19.24	19.4
50.72	25.9	18.25	19.0
47.65	26.0	15.71	18.0
46.69	25.6	14.95	17.7
45.07	25.0	14.86	18.1
41.04	25.8	11.90	16.1
40.96	25.4	10.21	14.8
39.50	24.4	8.48	13.0
35.14	23.9	6.32	11.9
34.49	24.1	3.15	7.8

Calibration Data for Steam Orifice.

Inlet Throttled.

<u>Corrected Differential in Inches of Mercury</u>	<u>Discharge in pounds of steam per minute</u>
64.42	28.0
63.55	27.3
62.80	26.9
61.95	26.5
61.14	26.3
60.02	26.2
59.13	25.9
52.41	22.9
50.15	22.1
49.37	21.8
38.69	17.4
37.87	17.2
30.68	14.4
29.59	13.9
20.56	10.3
17.88	9.4
12.15	7.0
5.52	3.6

Calibration on Thermo Couples

Deflec-
tion on
Millivolt-
meter #1271

Deflection on Millivoltmeter #20

<u>Standard Pt.-Pt.Rd.</u>	<u>#3 Couple</u>	<u>#4 Couple</u>	<u>#5 Couple</u>	<u>#6 Couple</u>	<u>Temp. in F°</u>
1.0	3.1	3.3	3.8	5.2	341
1.4					421
2.0	6.7	6.3	7.3	10.2	550
2.2					593
3.0	8.8	9.0	9.3	16.5	764
3.2					799
4.0	10.4	10.7	11.0	22.3	986
5.0	12.0	12.0	12.7	27.3	1212
6.0	13.8	13.7	14.6	33.1	1402
7.0	16.1	16.0	16.9	39.5	1592
8.0	18.8	18.5	19.5	45.3	1752
9.0	20.8	21.0	22.0	51.2	1932
10.0	22.6		23.6		2092
11.0					2252

CALIBRATION CURVE

for 12" Pt. Pt. Rd. Couple

<u>Temp. F°</u>	<u>Millivolts</u>
212	.64
392	1.39
572	2.27
752	3.20
932	4.17
1112	5.17
1292	6.20
1472	7.27
1652	8.36
1832	9.50
2012	10.68
2192	11.88

Calibration of Thermo Couples with
Recording Millivoltmeter.

Deflection on Millivolt- meter #1271	Deflection of Recorder Chart			Temp. in °F
	#5 Couple	#7 Couple	#7 couple with resis- tance.	
1.0	4.25	3.1	1.9	341
1.4				421
2.0	7.6	5.6	3.7	550
2.2				593
3.0	10.4	8.0	5.2	764
3.2				799
4.0	12.4	10.3	6.7	986
5.0	14.0	12.9	8.6	1212
6.0	15.7	15.8	10.1	1402
7.0	18.6	18.8	12.1	1592
8.0	21.5	22.1	14.2	1752
9.0	24.0	25.6	16.3	1932
10.0		27.1	18.9	2092
11.0				2252

Calibration of Fery Pyrometer

<u>Millivolts Deflection</u>		<u>Temp. in F°</u>
<u>Full Open</u>	<u>Half Open</u>	
0.07		572
0.14		752
0.25		932
0.41		1112
0.63		1292
0.935	0.22	1472
1.34	0.30	1652
1.85	0.43	1832
2.50	0.585	2012
3.30	0.775	2192
3.72		2282
	1.01	2372
	1.29	2552
	1.63	2732
	2.01	2912
	2.475	3092
	3.01	3272
	3.60	3452

CALIBRATION OF PITOT TUBES

12" Pipe (Primary Blast)

<u>Gage</u>	<u>Pressure # per sq.in.</u>		<u>Temperature ° C</u>		<u>Volume cu.ft. per min.</u>	
	<u>Initial</u>	<u>Final</u>	<u>Initial</u>	<u>Final</u>	<u>Exhaust</u>	
8	94.18	88.63	15.4	15.4	9.3	1372
10	117.30	110.90	20.7	20.7	15.5	1586
12	101.00	93.90	21.8	21.7	17.0	1765
12	114.07	106.32	16.3	16.3	11.3	1970
12	94.60	86.30	21.7	21.5	15.6	2052
14	128.75	120.29	28.5	28.3	22.5	2085
14	137.64	127.75	20.7	16.4	14.4	2320
16	127.75	118.96	16.4	16.3	11.4	2160
16	112.64	103.86	27.5	27.5	20.3	2185

8" Pipe (Secondary Blast)

6	103.90	101.70	16.7	16.7	11.7	546
6	85.90	83.30	16.7	16.7	12.8	642
8	91.10	88.40	16.7	16.7	12.9	670
8	115.00	112.00	17.0	17.0	13.3	752
12	118.70	115.00	17.4	17.4	13.6	930
12	98.10	94.00	16.7	16.7	13.8	1030
16	123.70	118.70	17.4	17.4	14.8	1250

Volume of Holder as computed from measurements

3608.5 cu.ft.

METER CALIBRATIONS

Holder #2 used during Calibration.

Water level on Meter #1 6-5/8"

Water level on Meter #2 5 1/4"

Circumference of holder #2 - - 204'7"

Outside Temperature - - - - - 32° F.

<u>Meter #1</u>			<u>Meter #2</u>			<u>Holder #2</u>	
Reading	Temp ° F.		Reading	Temp. °F.		Sheets	Rivets
	Inlet	Outlet		Inlet	Outlet		
00689010	64	54	64500180	59	67	6	27
00694900	64	55	64502160	56	67	6	0
00701150	64	54	64504100	56	68	5	0
00707450	64	54	64506180	57	68	4	0
00713630	64	54	64508220	56	70	3	0

From the above, the meters were found to be 2.7% slow.

All meter readings used in calculations were corrected by this amount.

CALIBRATION OF RELIEF HOLDER #1.

Volume in cubic feet at 60° F.

<u>Rivets</u>	<u>Sheets</u>						
	0	1	2	3	4	5	6
0	0	3500	7000	10500	14000	17500	21000
1	100	3600	7100	10600	14100	17600	21100
2	200	3700	7200	10700	14200	17700	21200
3	300	3800	7300	10800	14300	17800	21300
4	400	3900	7400	10900	14400	17900	21400
5	500	4000	7500	11000	14500	18000	21500
6	600	4100	7600	11100	14600	18100	21600
7	700	4200	7700	11200	14700	18200	21700
8	800	4300	7800	11300	14800	18300	21800
9	1000	4500	8000	11500	15000	18500	22000
10	1100	4600	8100	11600	15100	18600	22100
11	1200	4700	8200	11700	15200	18700	22200
12	1300	4800	8300	11800	15300	18800	22300
13	1400	4900	8400	11900	15400	18900	22400
14	1500	5000	8500	12000	15500	19000	22500
15	1600	5100	8600	12100	15600	19100	22600
16	1700	5200	8700	12200	15700	19200	22700
17	1800	5300	8800	12300	15800	19300	22800
18	1900	5400	8900	12400	15900	19400	22900
19	2000	5500	9000	12500	16000	19500	23000

CALIBRATION OF RELIEF HOLDER #1.

Volume in cubic feet at 60° F.

<u>Rivets</u>	<u>Sheets</u>						
	0	1	2	3	4	5	6
20	2100	5600	9100	12600	16100	19600	23100
21	2200	5700	9200	12700	16200	19700	23200
22	2300	5800	9300	12800	16300	19800	23300
23	2400	5900	9400	12900	16400	19900	23400
24	2500	6000	9500	13000	16500	20000	23500
25	2700	6200	9700	13200	16700	20200	23700
26	2800	6300	9800	13300	16800	20300	23800
27	2900	6400	9900	13400	16900	20400	23900
28	3000	6500	10000	13500	17000	20500	24000
29	3100	6600	10100	13600	17100	20600	24100
30	3200	6700	10200	13700	17200	20700	24200
31	3300	6800	10300	13800	17300	20800	24300
32	3400	6900	10400	13900	17400	20900	14400
33	3500	7000	10500	14000	17500	21000	24500

CALIBRATION OF RELIEF HOLDER #2.

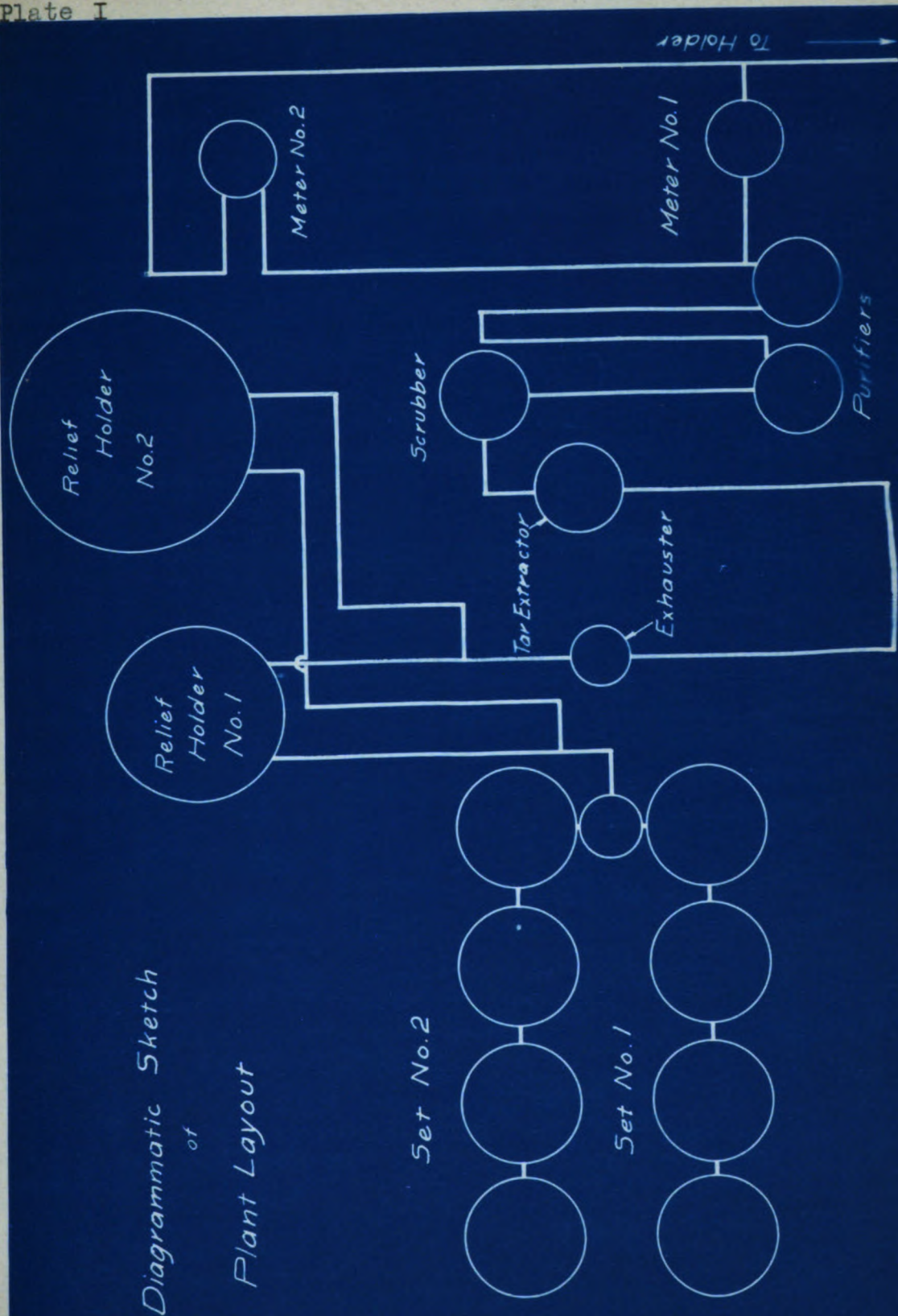
Volume in cubic feet at 60° F.

<u>Rivets</u>	<u>Sheets</u>							
	0	1	2	3	4	5	6	7
0	0	8000	16000	24000	32000	40000	48000	56000
1	300	8300	16300	24300	32300	40300	48300	56300
2	500	8500	16500	24500	32500	40500	48500	56500
3	800	8800	16800	24800	32800	40800	48800	56800
4	1100	9100	17100	25100	33100	41100	49100	57100
5	1300	9300	17300	25300	33300	41300	49300	57300
6	1600	9600	17600	25600	33600	41600	49600	57600
7	1900	9900	17900	25900	33900	41900	49900	57900
8	2100	10100	18100	26100	34100	42100	50100	58100
9	2400	10400	18400	26400	34400	42400	50400	58400
10	2700	10700	18700	26700	34700	42700	50700	58700
11	2900	10900	18900	26900	34900	42900	50900	58900
12	3200	11200	19200	27200	35200	43200	51200	59200
13	3500	11500	19500	27500	35500	43500	51500	59500
14	3700	11700	19700	27700	35700	43700	51700	59700
15	4000	12000	20000	28000	36000	44000	52000	60000
16	4300	12300	20300	28300	36300	44300	52300	60300
17	4500	12500	20500	28500	36500	44500	52500	60500
18	4800	12800	20800	28800	36800	44800	52800	60800
19	5100	13100	21100	29100	37100	45100	53100	61100

CALIBRATION OF RELIEF HOLDER #2.

Volume in cubic feet at 60° F.

<u>Rivets</u>	<u>Sheets</u>							
20	5300	13300	21300	29300	37300	45300	53300	61300
21	5600	13600	21600	29600	37600	45600	53600	61600
22	5800	13800	21800	29800	37800	45800	53800	61800
23	6100	14100	22100	30100	38100	46100	54100	62100
24	6400	14400	22400	30400	38400	46400	54400	62400
25	6600	14600	22600	30600	38600	46600	54600	62600
26	6900	14900	22900	30900	38900	46900	54900	62900
27	7200	15200	23200	31200	39200	47200	55200	63200
28	7400	15400	23400	31400	39400	47400	55400	63400
29	7700	15700	23700	31700	39700	47700	55700	63700
30	8000	16000	24000	32000	40000	48000	56000	64000

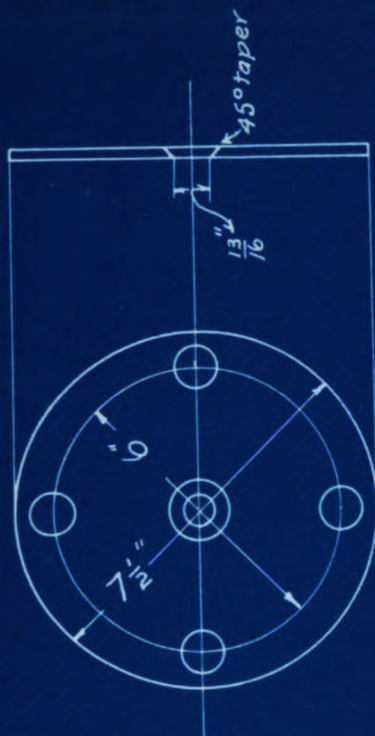


Diagrammatic Sketch
of
Plant Layout

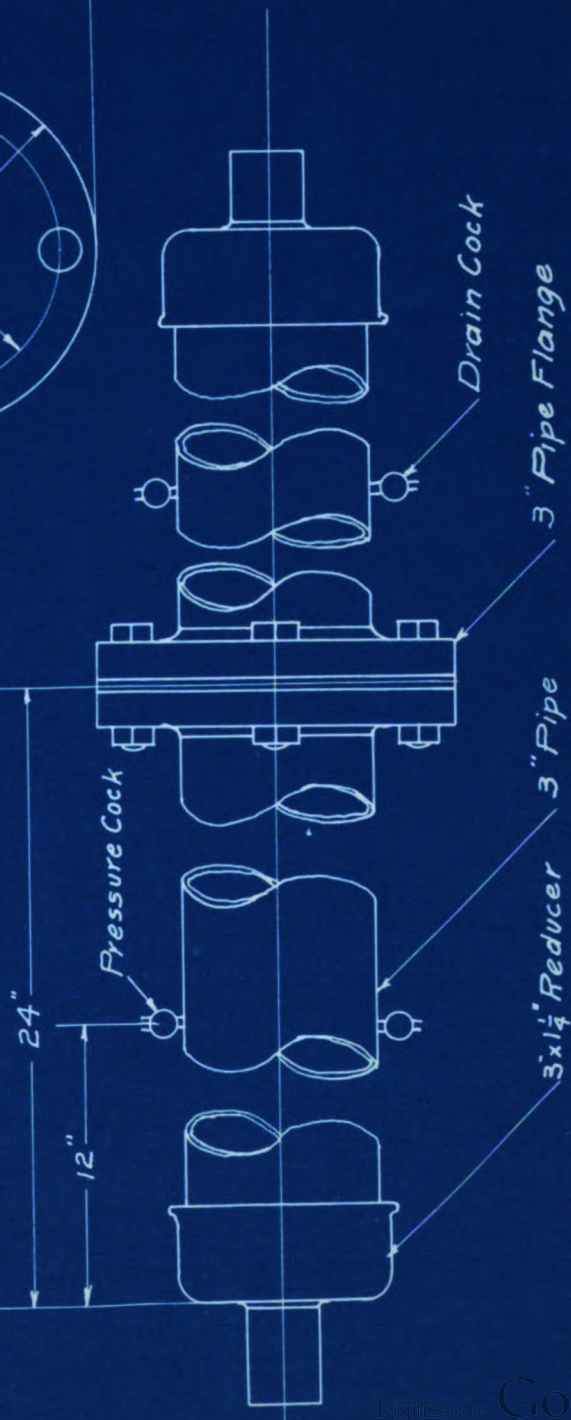
Set No. 2

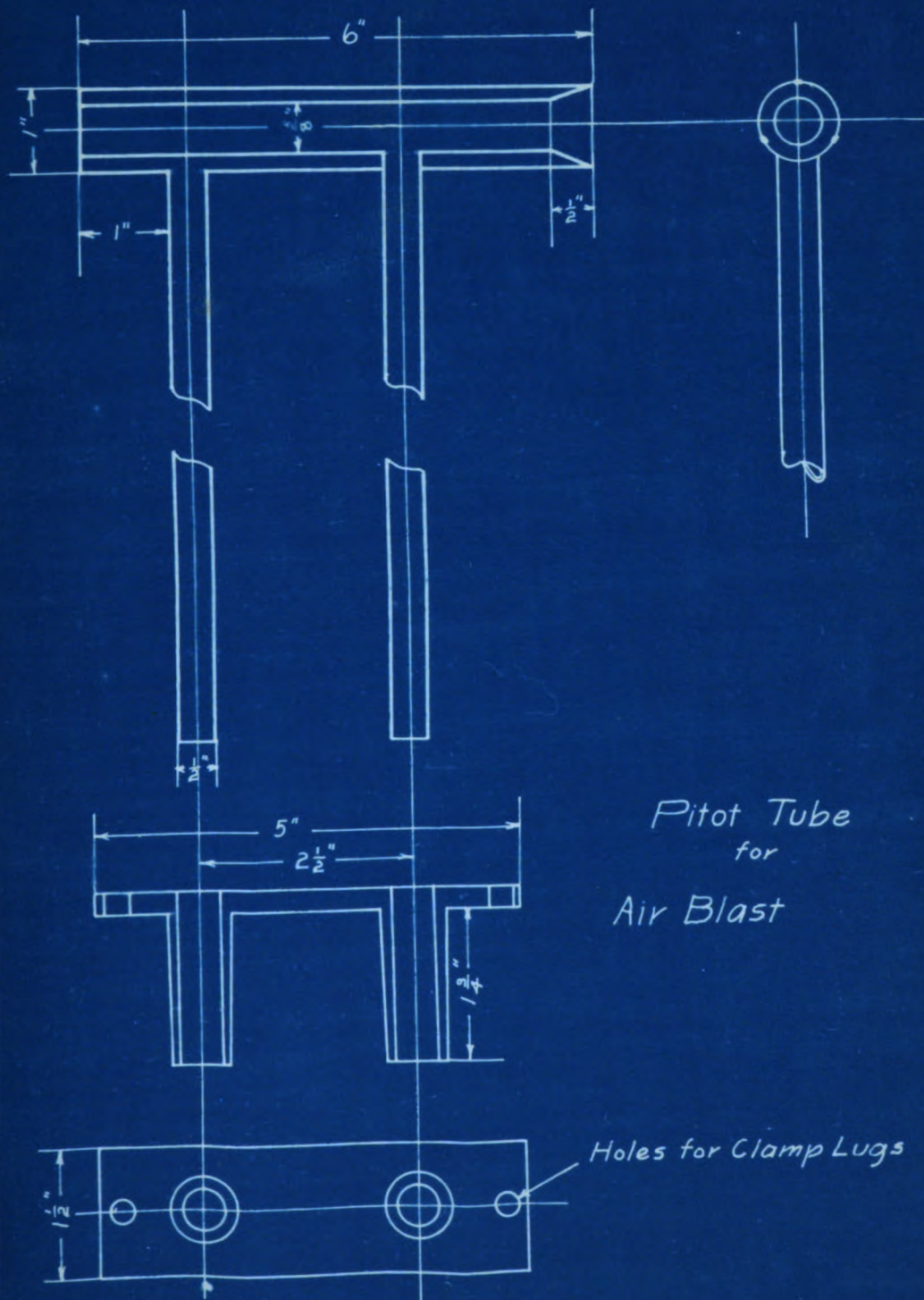
Set No. 1

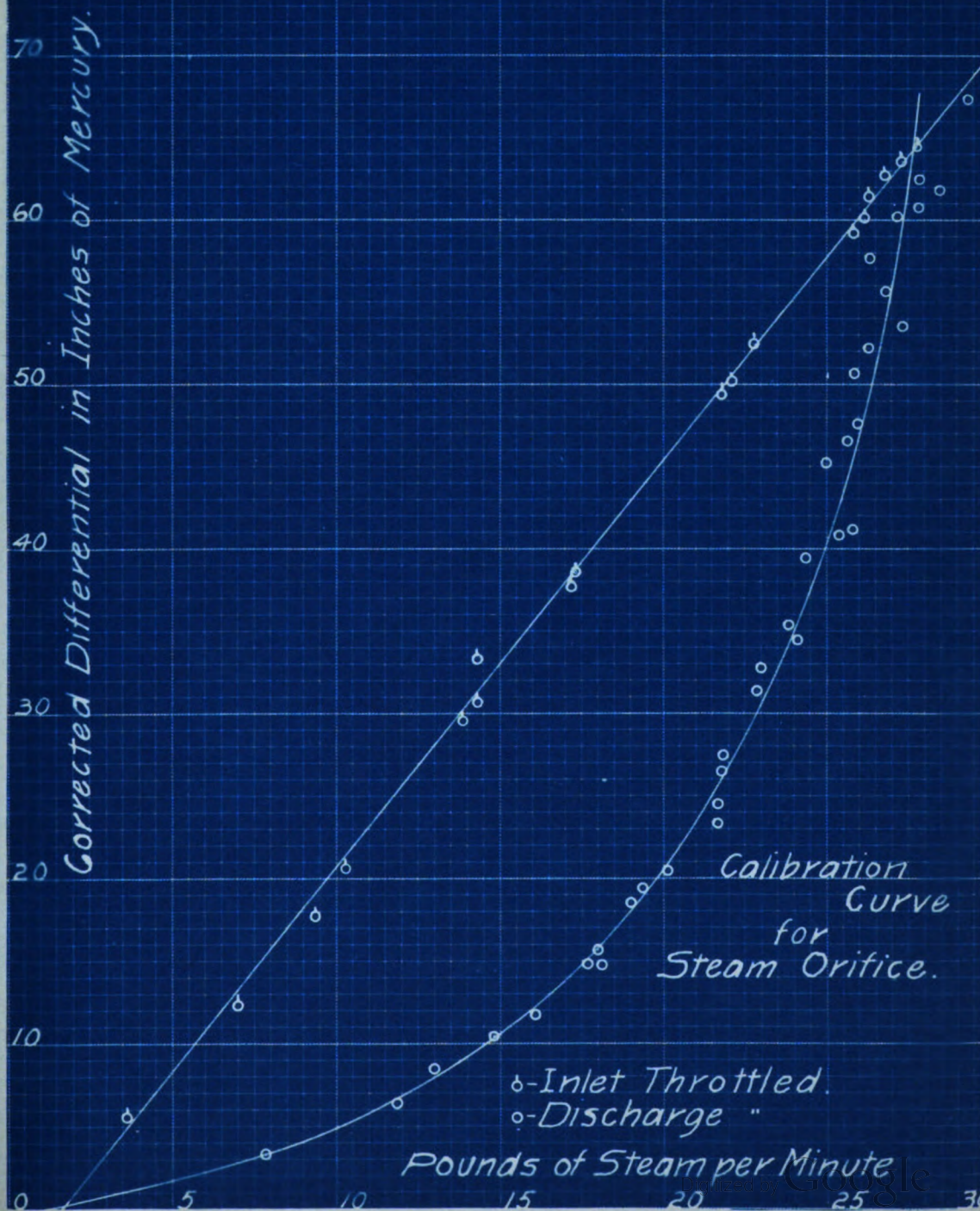
Brass Orifice Plate
 $\frac{3}{16}$ " thick

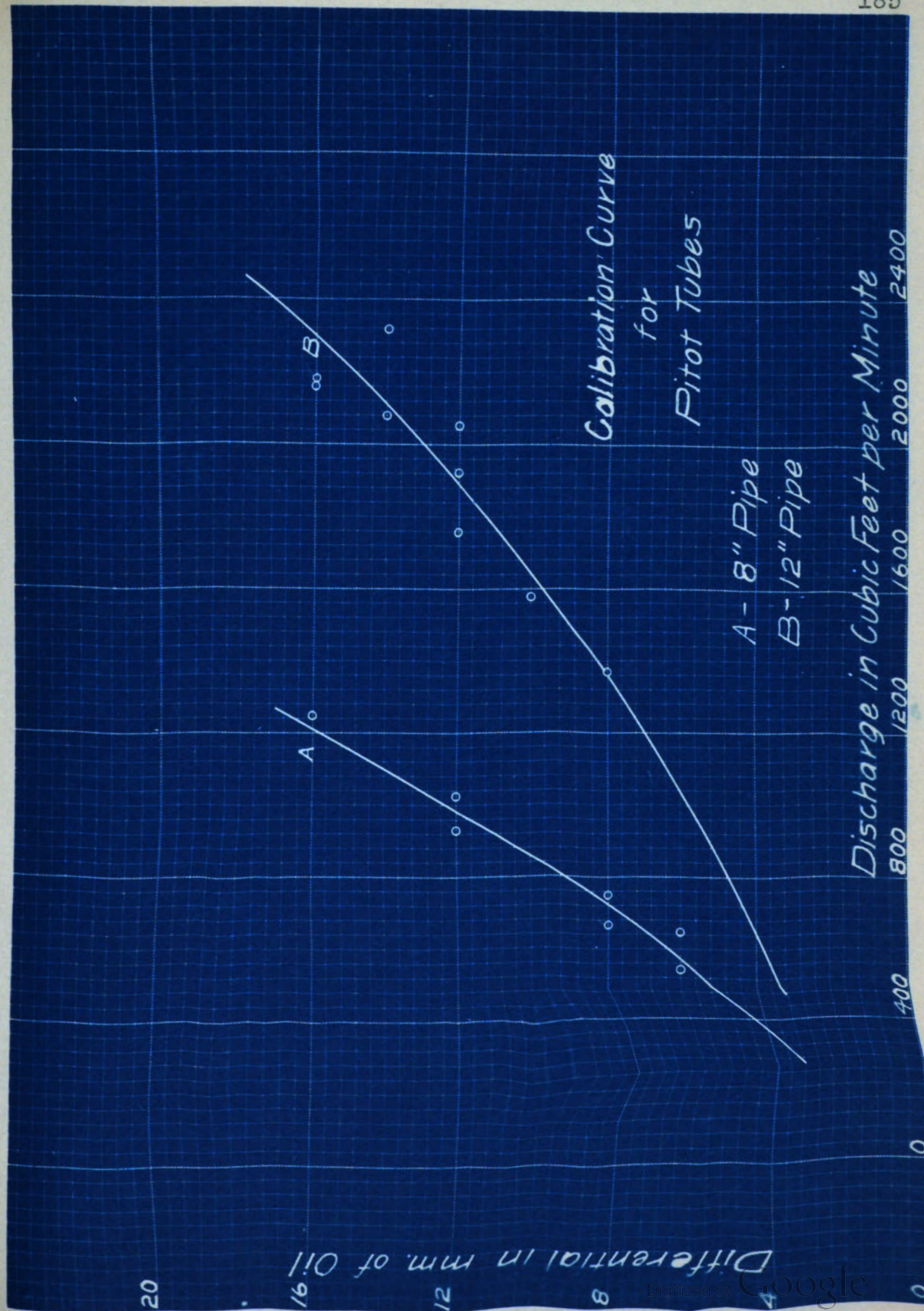


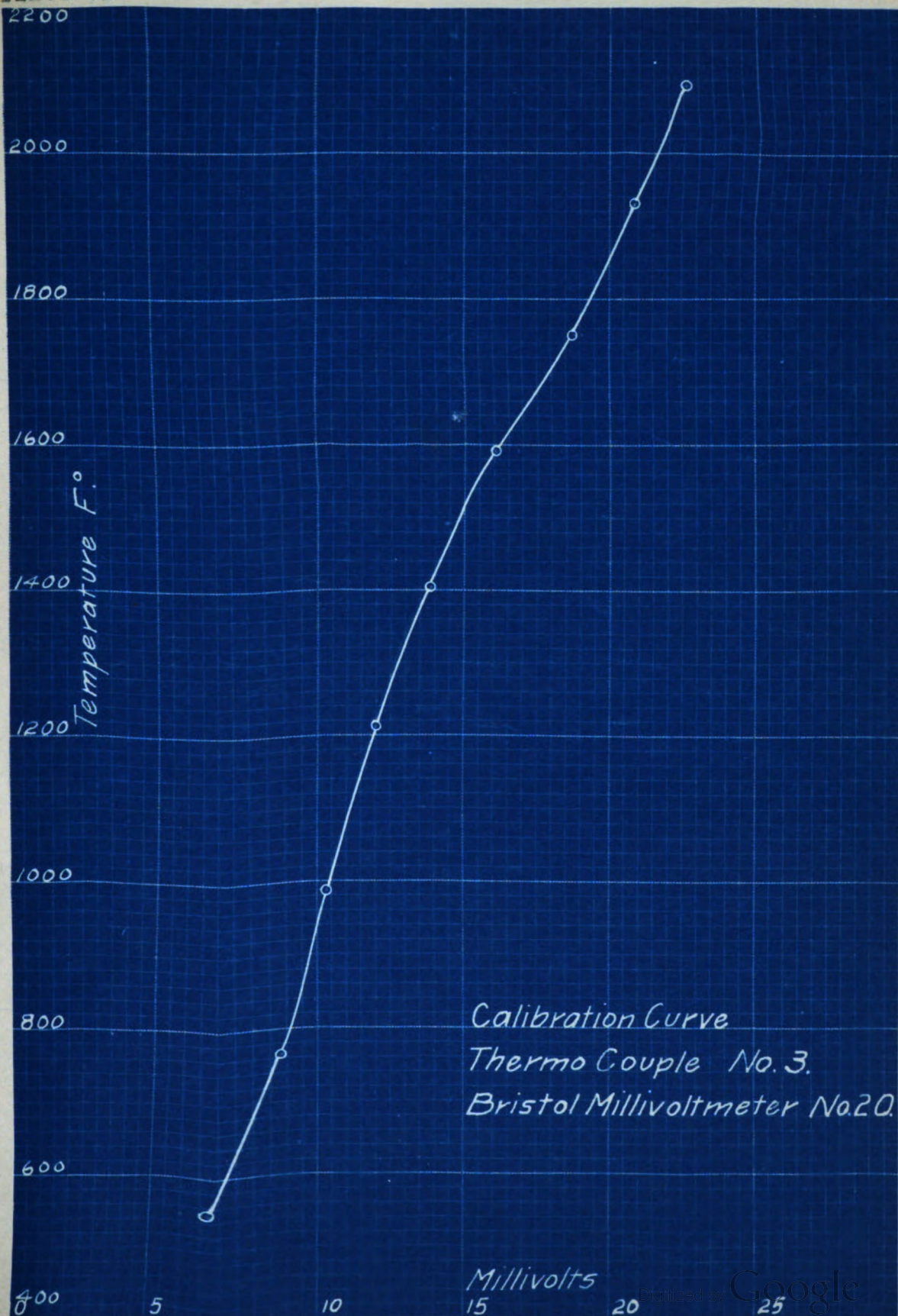
Sketch
of
Steam Meter











2200

2000

1800

1600

1400

1200

1000

800

600

400

Temperature F.

5

10

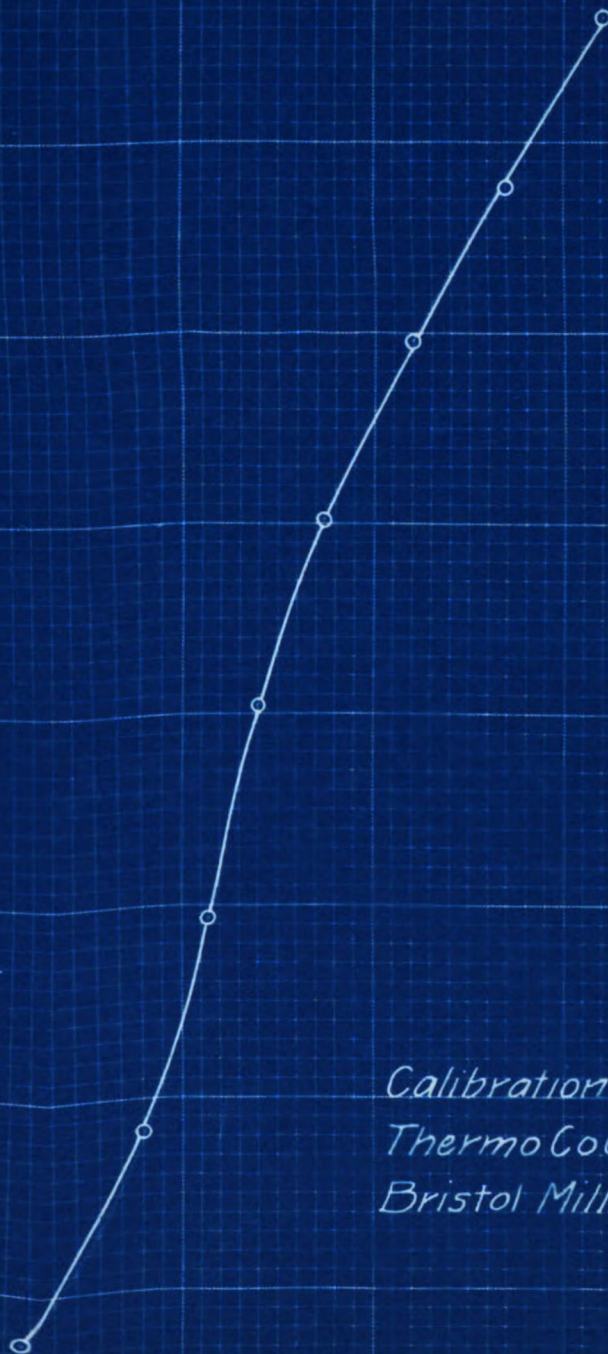
Millivolts

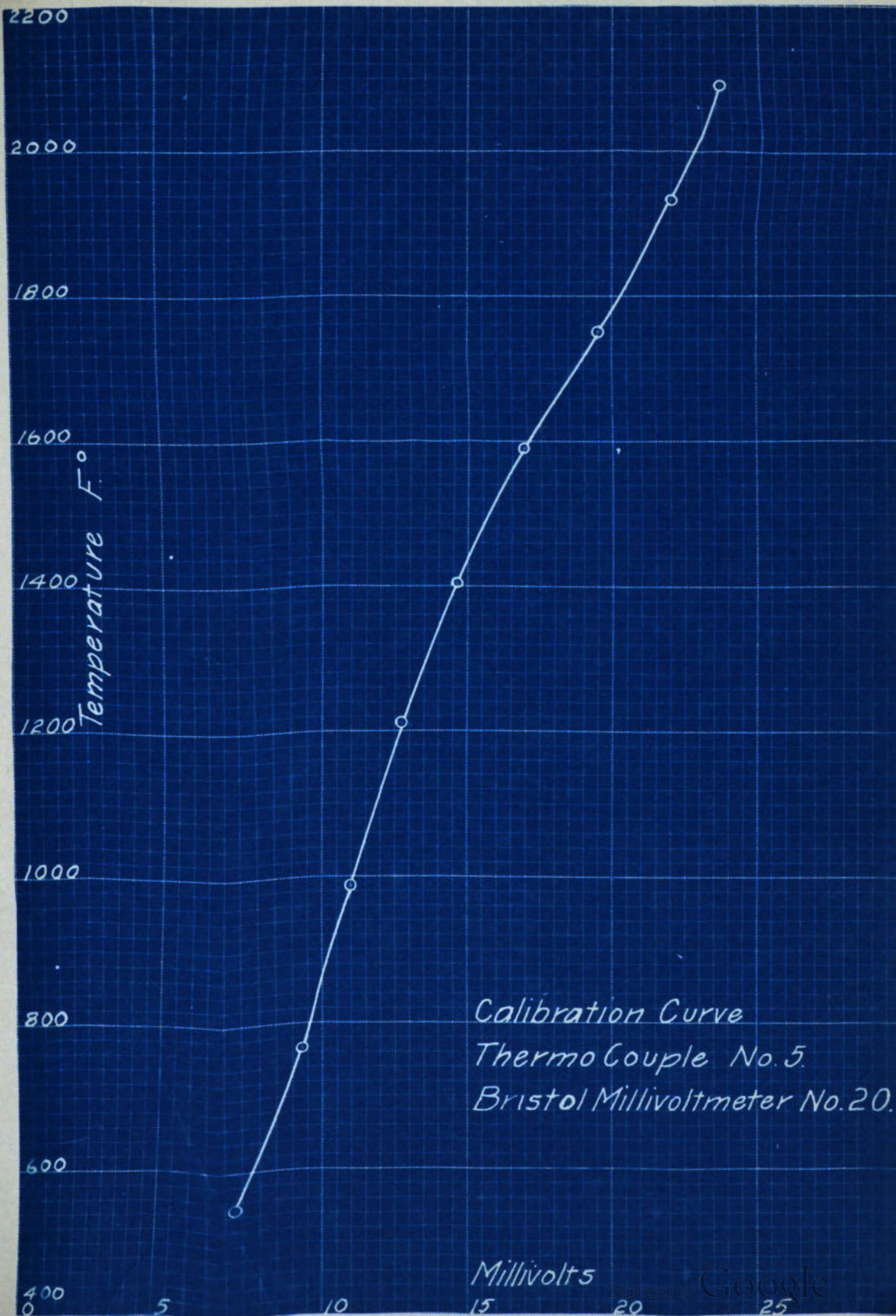
15

20

25

Calibration Curve
ThermoCouple No. 4.
Bristol Millivoltmeter No. 20.





2000

1800

1600

1400

1200

1000

800

600

Temperature F.

Calibration Curve

Thermo Couple No. 6.

Bristol Millivoltmeter No.

Millivolts

400

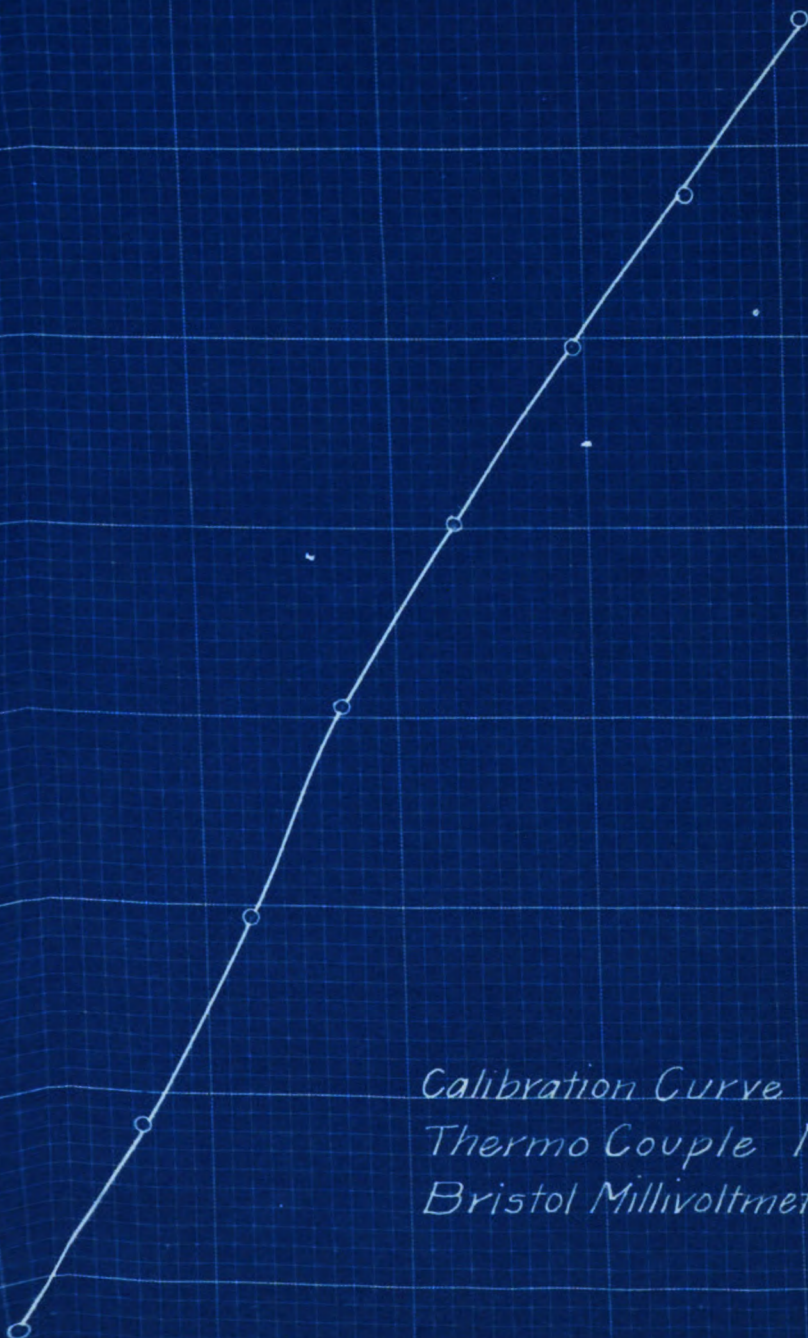
10

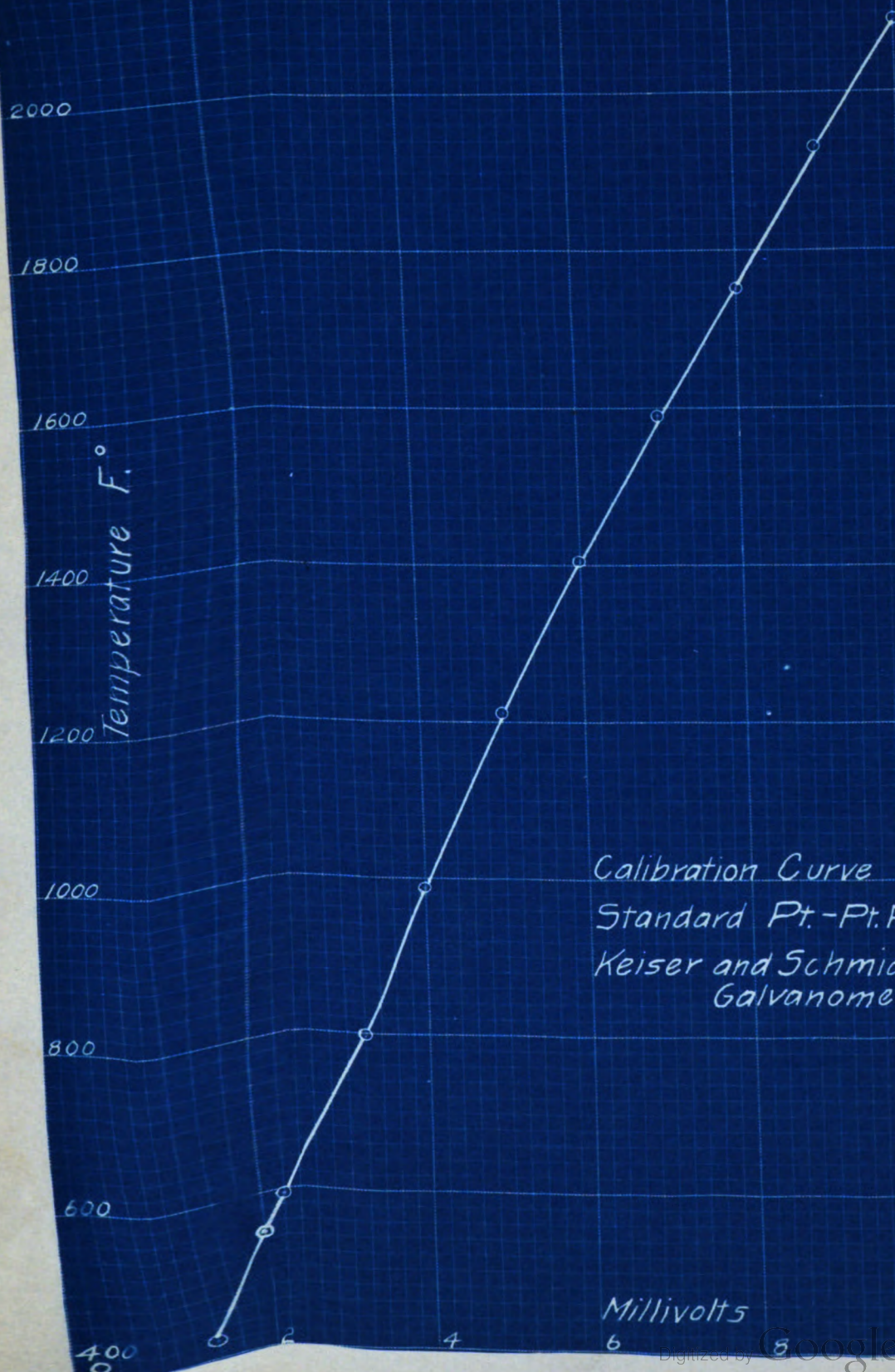
20

30

40

50





Calibration Curve

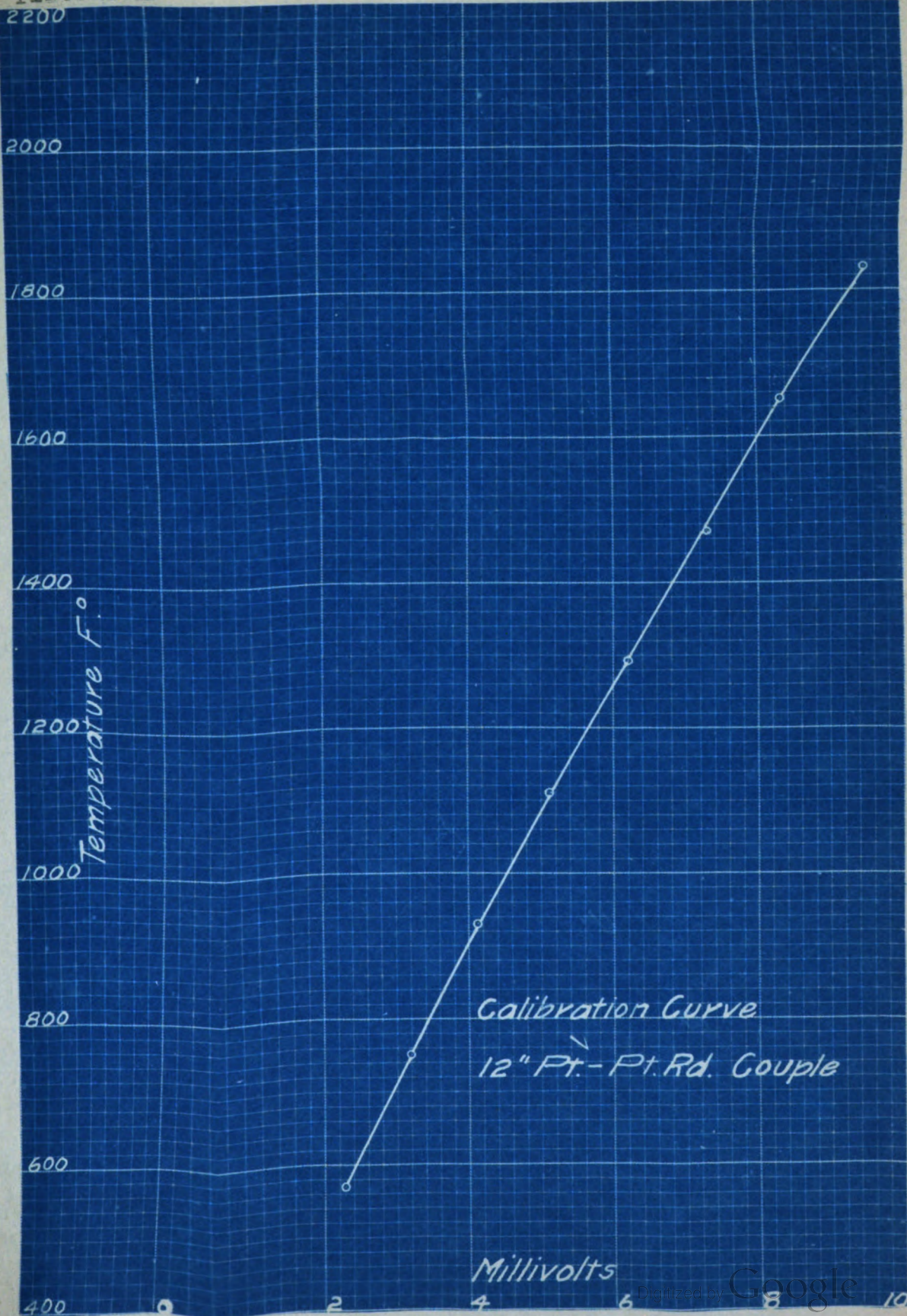
Standard Pt.-Pt.Rd. Coupl

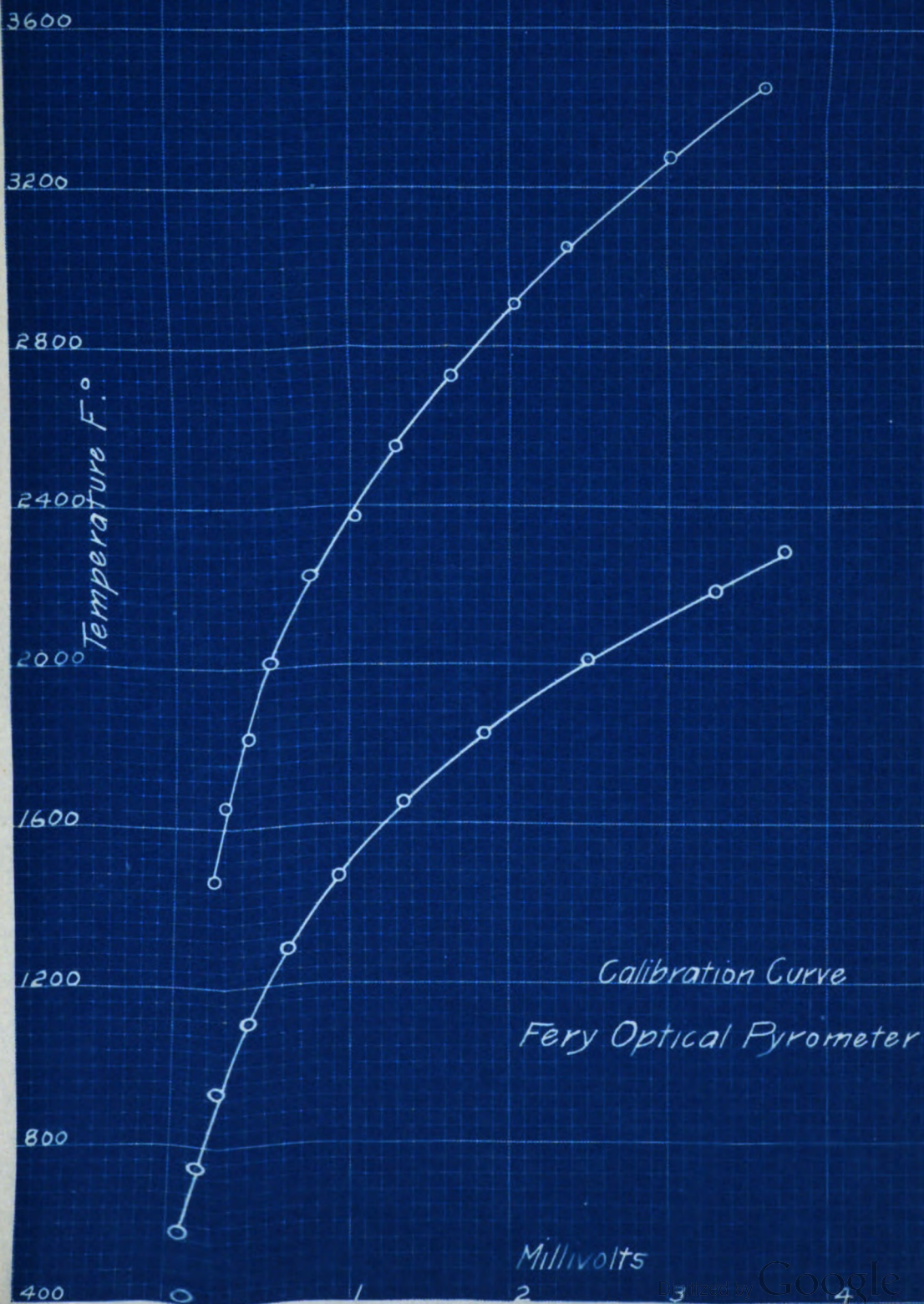
Keiser and Schmidt

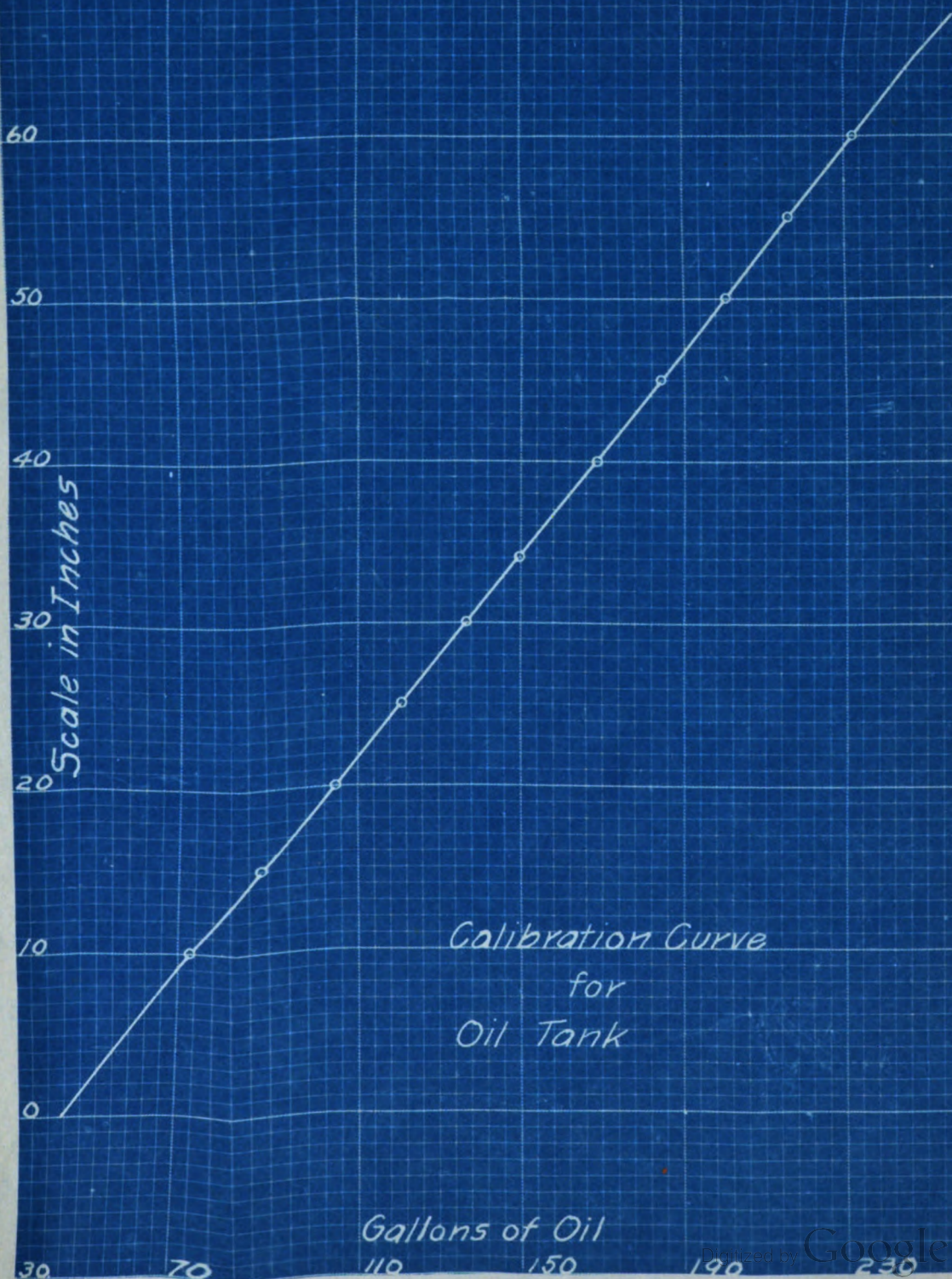
Galvanometer No. 1

Millivolts

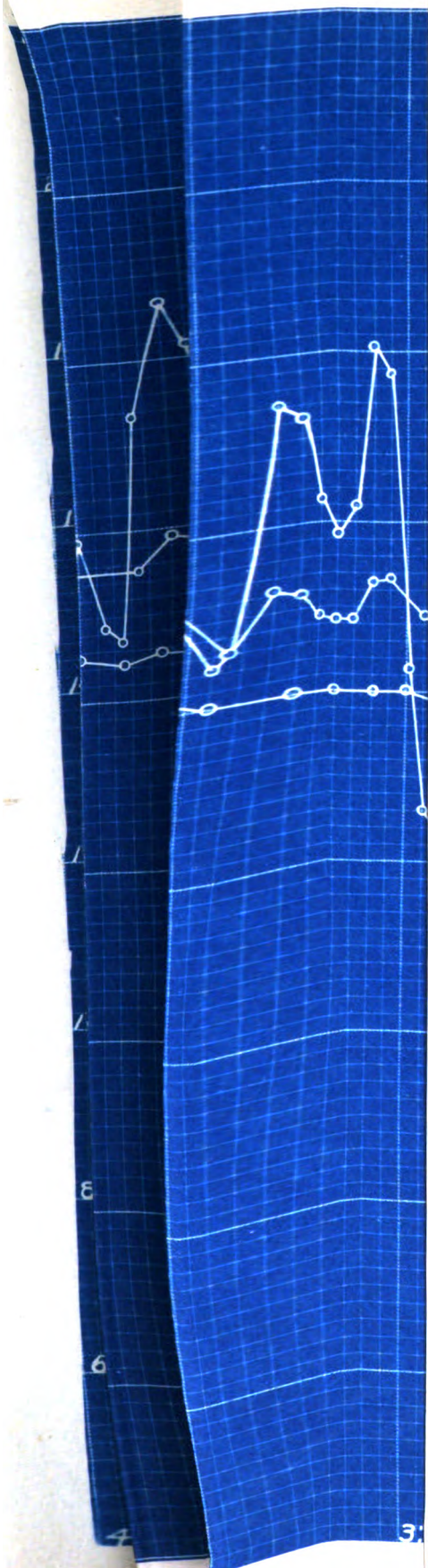
6



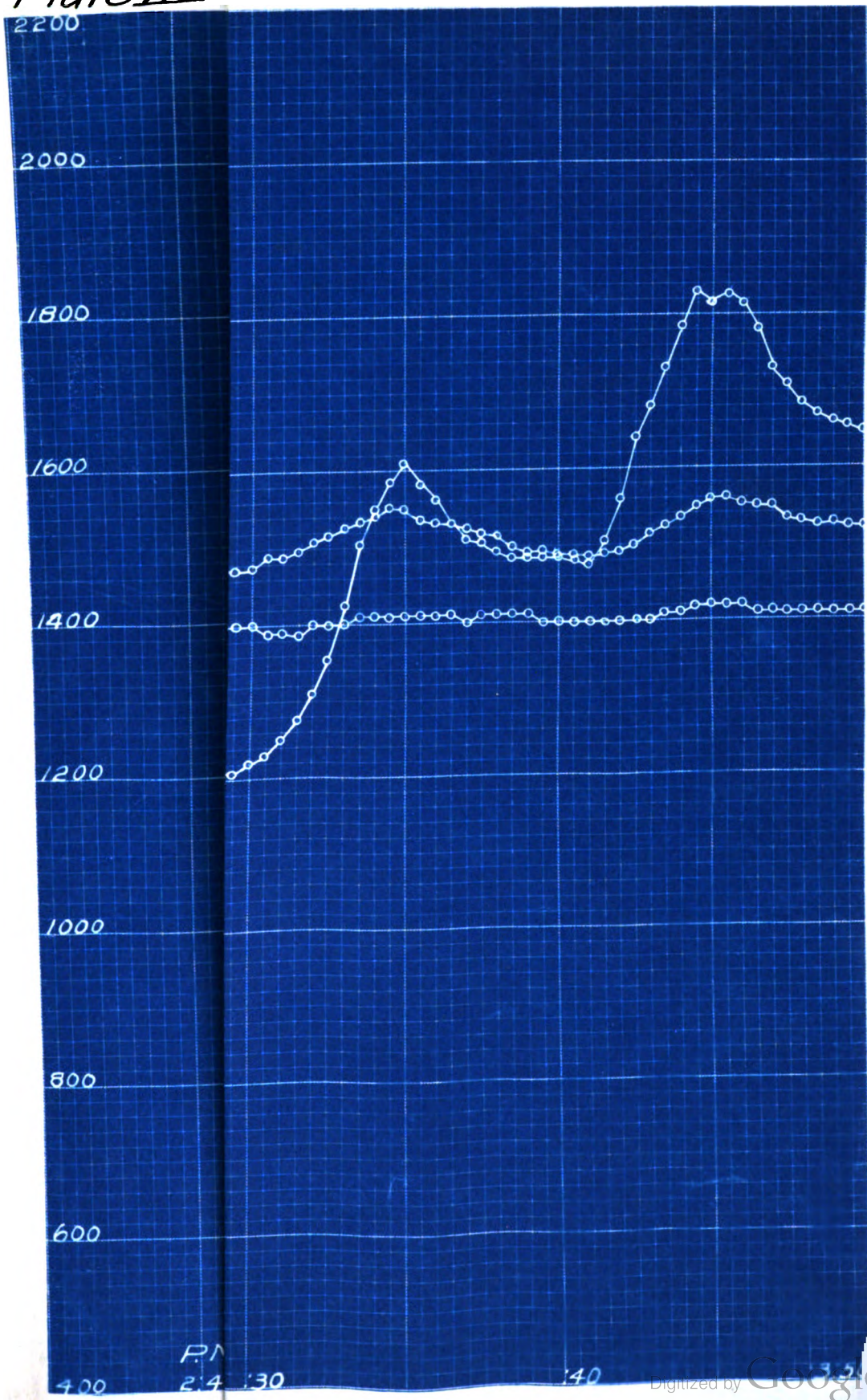


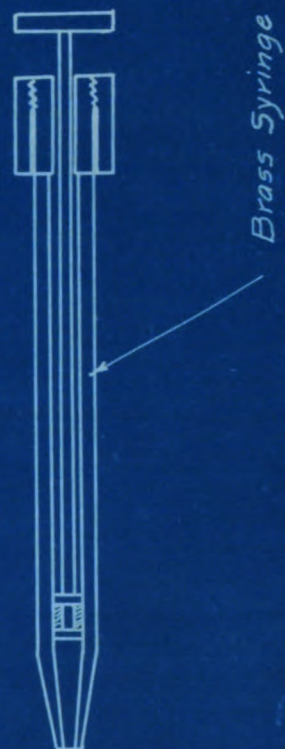


196









Monel Metal Cartridge for Oil Determinations

220

187

140

100

60

20

0

Water

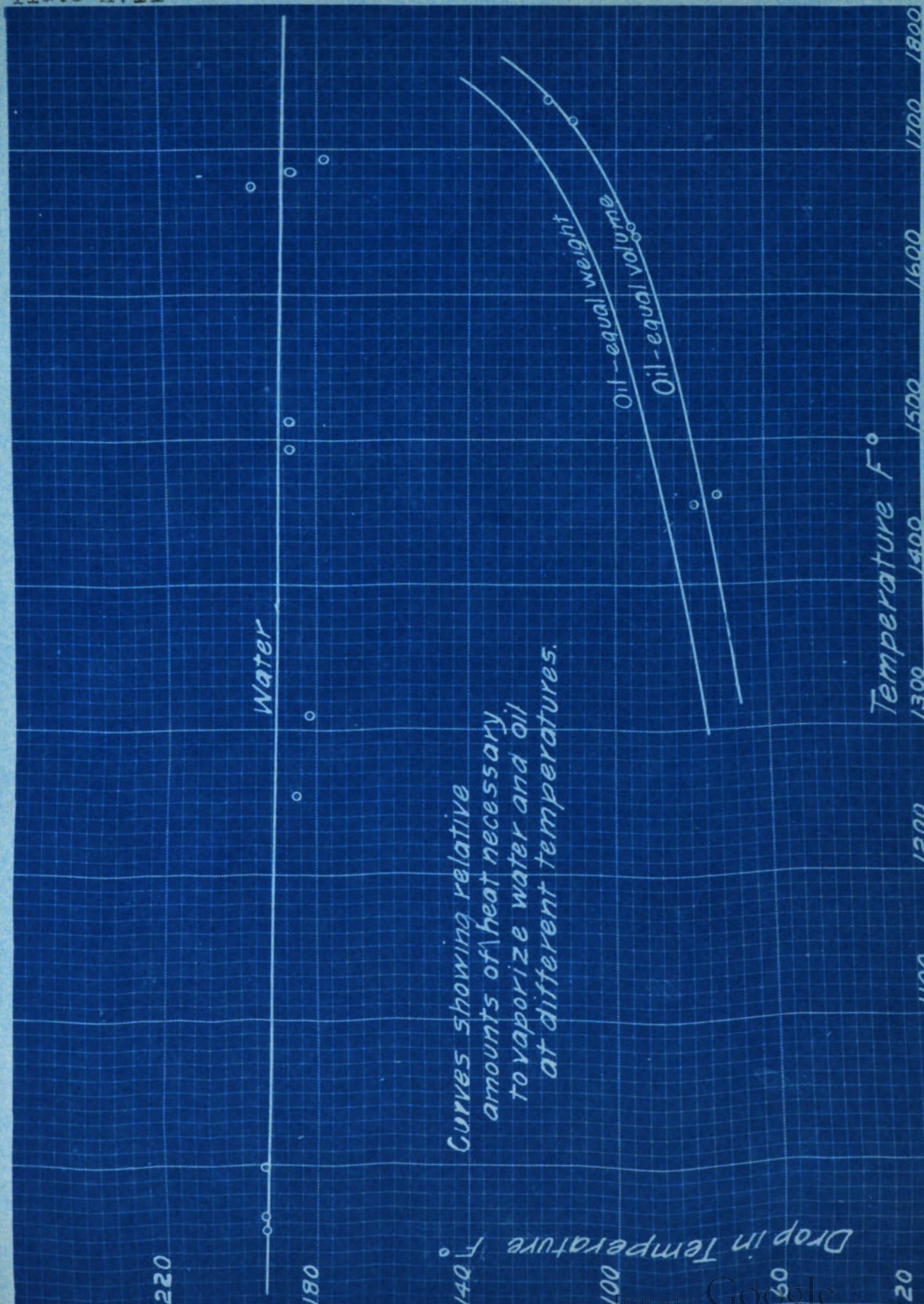
Curves showing relative
amounts of heat necessary
to vaporize water and oil
at different temperatures.

Oil - equal weight
Oil - equal volume

Temperature F°

1000 1100 1200 1300 1400 1500 1600 1700 1800

Drop in Temperature F°



Heat Balance Generator Test No. 1.

Sensible heat in blue water gas $\rightarrow$ 12.28% 28.01%
To produce blue water gas

9.87% to
superheat dry steam

6.21% to vaporize
coke moisture

2.43% to superheat
moisture in gas

0.81% to vaporize
blast moisture

0.38% to vaporize
steam moisture

33.51%
Sensible heat in
blast gases

1.96% Left in fuel bed

1.30% Left in brick

2.64% Radiation

0.60%
Unaccounted for

Input
100%

Heat Balance

Carburettor and
Superheater-
Test No. 1

18.10% Sensible
heat in crack
carburetted oil
gas

10.88%
to

45.50% Stored in brickwork

13.20% Sensible heat
in blast gases

4.77% Radiation

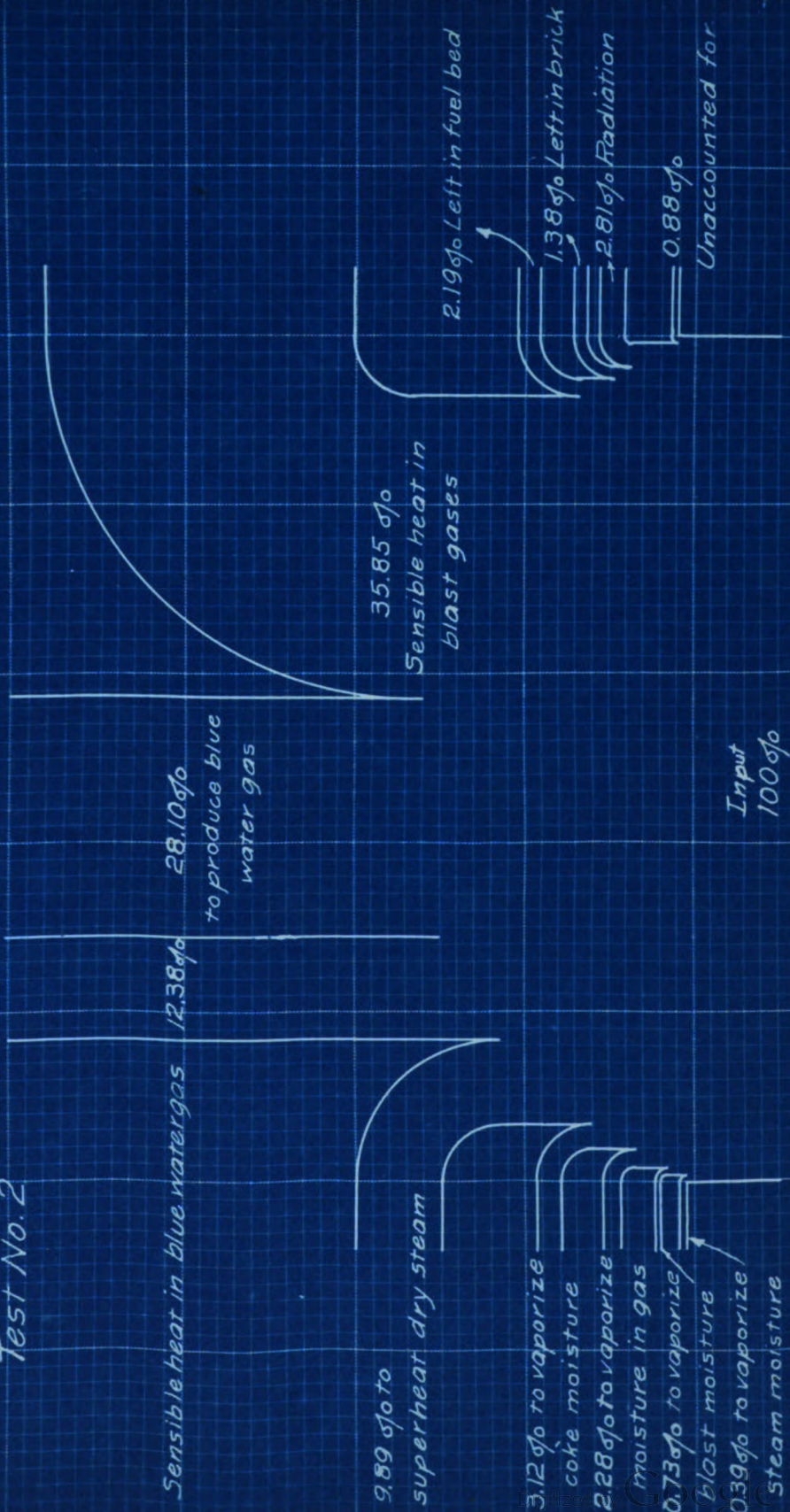
0.46% Unaccounted for

Input
100%

6.83% absorbed
by reduction of CO_2

0.26% to superheat
air moisture

Heat Balance Generator- Test No. 2



Heat Balance Carburettor and Superheater— Test No. 2

17.60% sensible
heat in
carburetted
gas

10.10%
to
crack
oil

4.770% Stored in brickwork

13.30% sensible heat in
blast gases

4.95% Radiation

0.63% Unaccounted for

Input
100%

5.85% absorbed
by reduction of CO_2

0.17% to superheat
air moisture

Thesis of Messrs. Kartak + Steinberg

Approved by

O. L. Kowalka, Instructor in Chem. Eng.

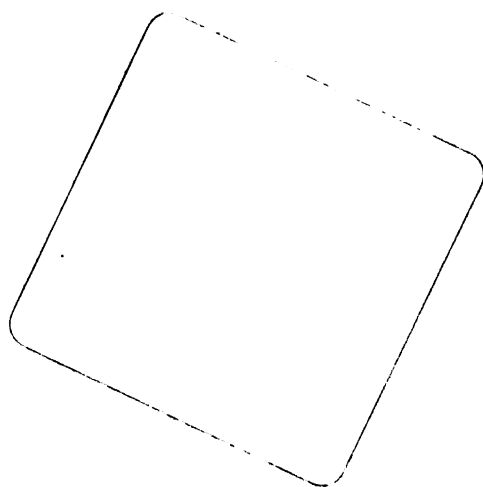
Countersigned by

C. F. Burgess, Prof. of App. Electrochemistry

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